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THE ENGINEER

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IMPACT OF AUTOMATION

Without adding very much to engineers' knowledge of the subject, the report of the Department of Scientific and Industrial Research on "Automation," issued last week, amounts to a very useful review of the whole subject. Neatly in his preface, Sir Ben Lockspeiser puts automation into its evolutionary perspective. "Those who think in terms of evolutionary growth of labour-saving mechanical and electronic devices in business offices and production shops show some irritation at an unnecessary new word and an ugly one at that. But the development and application of the automatic electronic computer . . . for the integration and control of office procedures and manufacturing processes is something new, beckoning us towards the electronic office and the automatic factory of which we can already see the outlines." Thereafter, nearly a half of the report describes and comments upon what has already been done to introduce automation into factories and offices. Since a great deal of this material has already, in a number of different guises, been published elsewhere, it is, we think, the second part of the report, reviewing the impact on management and upon labour of automation, and drawing conclusions from the discussion, that will attract greater attention.

But, unfortunately, the report, having no doubt been written before there was any significant union reaction towards the introduction of automation, seems rather seriously to under-estimate the labour troubles that may lie in store for firms introducing transfer machines and the like. Nevertheless, the facts are brought out with great clarity and are discussed in some detail. The general conclusion drawn by many commentators that one of the consequences of automation must be to increase the proportion of skilled to unskilled men in a factory remains unchanged. But it is also emphasised that the nature of the skills needed will be altered, and that amongst operatives, as opposed to maintenance men, less rather than more skill may be called for. The new skills required will depend less upon "handicraft" ability and more and more upon intelligent reaction to a situation; and an ability to appreciate the consequences of any simple action upon the whole output of a transfer machine or the whole operation of a process will become more important than an ability to carry out a comparatively complicated series of actions affecting a single machine. A distinction needs to be drawn between the partially "automated" factory and the fully automatic one; for in the former, though not in the latter, the speed at which operatives have to work may well be set by the machine, a situation usually disliked, for obvious human reasons, by the operatives. Yet undoubtedly the general trend of the effect upon workers must be to favour those, whether at present skilled or not, who have "perceptual" and "conceptional" ability—that is, those who can absorb nformation from instruments or signals, interpret it and take appropriate action. Whatever the present degree of skill, new training, though not necessarily prolonged training, will be necessary to bring about the changed attitude. Younger men, maybe, will welcome these changes. But what, we wonder, will older men think of them ? For older dogs seldom welcome the need to learn new tricks and all men dislike a feeling that as the years pass there may be a decline in the demand for the particular skills they command. We find it difficult therefore to accept as readily as the writers of the report that the "possibility of automation causing unemployment . . . is unlikely to be a serious problem if its introduction is not too rapid." Upon the national scale its introduction may, indeed, prove insufficiently rapid to affect unemployment figures. But the reaction of labour to it is likely to be built not upon national, but on local efforts. Local unemployment created by the automation of single factories, local forced changes of employment to jobs at lower wage rates, local unemployment of older skilled men unwilling to be trained to new tricks, if frequently repeated, would unquestionably place union leaders in a very difficult position. And "consulting the unions in advance of each step," as wisely recom-

mended in the report, might well, under those circumstances, relapse into an argument rather than helpful consultation. It seems to us that if automation is to come without industrial troubles, then each and every application of it will need to be planned with care if the assistance, rather than the resistance, of unions is to be secured.

But if workers are likely to find some of the repercussions of automation uncomfortable, so, too, may managements. For it is very probable that new techniques of management will have to be worked out, no doubt with the assistance of certain process industries in which automation has already been carried very far. It is suggested in the report that men possessing managerial ability and economic understanding, but having no technical knowledge, are unlikely to make automation a success. There will need, therefore, to be more technologists at the top, and if they are to prove effective they will need to acquire more clarity about managerial and economic factors than their training at present gives them. It is interesting in that connection to note that the courses leading to a diploma in technology at technical colleges, discussed in the following article, are to include " some instruction in the principles of industrial organisation."

DIP. TECH. (ENG.)

The publication by the National Council for Technological Awards of a " Memorandum on the Recognition of Courses in Technical Colleges leading to the Diploma in Technology " has not done very much to clarify the situation. That this nation needs to educate many more men to a high technological standard than it does at present is undoubtedly true. But we are still left wondering whether the method outlined in the memorandum is the best way of doing it. The standard of the award is expected to be equivalent to that of an honours degree in a British university. But there are indications, notably in the remark that " at a suitable stage in the course students should be able to participate in a substantial project and facilities should be available for this purpose," and in a reference to " the fundamentals of science and technology and their application to development and design," that the content of courses will be less purely academic than those of a university. In this democratic age it may be thought to be an advantage that, at least in appearance, it is open to any technical college to submit courses for approval by the National Council. But, in fact, the document makes it very obvious that few will be able to do so. For the conditions governing the award, if strictly enforced, will automatically debar the majority of colleges from entering the field. They require colleges whose courses are approved to be liberally equipped and to have a staff equal in quality to that of a university. " The subjects constituting the course must be conducted in an environment where advanced studies are the main preoccupation of the staff " ; and it is not only " desirable for the college to have residential facilities," but it is intended " to make this a condition as soon as possible." Staff must have either " higher degrees and substantial academic experience " or " academic qualifications supported by industrial experience." There are to be included " persons to whom industry would go for advice " and it is essential that " staff engaged on the course should have opportunities for research." Differing interpretations of these conditions are, of course, open to the Council according to its mood. But if the Dip. Tech. is ever to earn a prestige equivalent to that of a university degree the interpretation will clearly have to be strict. For neither money nor men are available in sufficient quantity to equip and staff many colleges to provide so high a standard of training, and to approve courses at colleges insufficiently staffed and equipped would merely stultify the object of the scheme. There comes the rub. For it is difficult to see, educationally, what advantages this scheme has over alternative proposals, notably that of deliberately selecting a few existing technical colleges for advancement into technological colleges concentrating their activities on advanced training and of giving those colleges self-government or placing them under the wing of a university ; the more so as it is stressed in the memorandum that " the courses must include liberal studies." Indeed, it seems to us by no means improbable that evolution will take place in that direction. If the National Council is strict in interpreting its rules for the recognition of courses it well may. We hope it does.

The Engineer

100 Years Ago

(MAY 23, 1856)

" THE BRIDGES WE ARE GOING TO BUILD "

" That we are an ' eminently careful people ' might be reasonably inferred from the extreme slowness with which we do everything requiring more than a board of directors to control. Once entrusted to a ' Commission,' any public work, however desirable or urgently needed, becomes encased in a shell of tediousness, like a snail, and proceeds at a lively pace, measurable by the progress of that active crustacea. A man may build his own house, lay out his grounds, trim his banks, and throw over his bridges in no time. Or, associated with others, he will survey his line, execute his works, and send his locomotives puffing over the country in a relatively brief period ; but let him entrust a work, in which he is only generally interested, to a ' Commission,' and slowness and circumlocution become the order of the day.

" For illustration of this disagreeable fact, we need travel no further than the banks of Father Thames, whereon we shall see preparations that have been going on for some years for building two bridges, one near Chelsea, and the other adjoining to and over the site of the present tottering structure at Westminster. Under whose particular management these two promising works have been progressing, or not progressing, we need not inquire. We only know the facts which are patent to all . . . that the piers of the one edifice remained for some years as solitary beacons in the channel of the river, and that the scaffolding for the other has grown ancient in its idle service, while its cranes are rusting above and its piles rotting below. We sincerely condole with the unfortunate engineer who has had the credit of the designs for these works, but appears destined never to see them erected ; and we humbly advise him to abandon these tedious enterprises, and betake himself to the other great work on which he is engaged—the beautiful brick embankment of the Thames."

SAFETY AT WORK

One of the difficulties in accident prevention, whether in the factory or the home, the roads or elsewhere, is that so much reliance must be placed upon propaganda. The same thing, the same advice, has to be proferred over and over again ; and those who proffer it are always haunted by the fear that repetition *ad nauseam* must eventually so bore the recipient that he becomes hardened and fails any further to react. We fear, indeed, that few, other than those whose particular concern it is to try to reduce the number of factory accidents, will bother to read the excellent report published last week by the Industrial Safety Sub-Committee of the National Joint Advisory Council. Yet when it is remembered that out of a total of some seven million workers employed in factories over 450 are killed and about 160,000 injured in accidents each year ; that each year about 3 per cent of male and 1 per cent of female workers are the victims of reported accidents ; and that some 20,000,000 man days of work are lost each year through accidents ; the dimensions of the problem and its effect upon the national output can be discerned to be immense. Much, of course, has already been done. Guards on machines, protective clothing, ingenuity in design, have all been called into play positively to prevent accidents. But unfortunately such methods cannot cover all hazards. Safety can only be assured, as the report stresses, if it is accepted as a policy from the top to the bottom of an undertaking, and if that policy is reflected in the organisation and methods throughout the works. A major recommendation of the sub-committee, that a Standing National Committee representative of Government and industry, should be established " to keep under constant review progress in furthering all aspects of industrial safety, and, in particular, to consider requirements in the field of research," has already been acted upon. The National Joint Advisory Committee is to set up such a body.

A Seven Day Journal

Iron and Steel Institute

THE annual general meeting of the Iron and Steel Institute was held in London on Wednesday and Thursday of last week. At the opening session on Wednesday morning, Sir Charles Bruce-Gardner, Bt., the retiring president, was in the chair, and the formal business was transacted, followed by the presentation of the Institute's medals and prize awards. Sir Charles then inducted Dr. H. H. Burton to the presidential chair. Dr. Burton's presidential address dealt with problems and progress in steel manufacture and metallurgy, and extracts from it are printed on page 555. After the presidential address, the ninth Hatfield memorial lecture, entitled " The Fracture of Metals," was given by Professor N. F. Mott. On Wednesday evening, a company of members and guests, numbering nearly 1500, assembled at Grosvenor House for the Institute's annual dinner. Dr. Burton was in the chair, and the principal after-dinner speaker was Lieut.-General Sir Ronald Weeks, who proposed the toast of " The Iron and Steel Institute and Industry." In the course of his speech, Sir Ronald said that the iron and steel industry, with its remarkable range of products, impinged on the economy of the country in almost every possible shape and form. The output of steel in most of the industrial countries of the world was often regarded as an indication of the prospects of industrial activity. In the case of this country, Sir Ronald commented, it was encouraging that the steady upward trend of the last few years was still being maintained. After Dr. Burton had responded, the toast of " The Guests " was proposed by Mr. Richard Mather, a past-president, and acknowledged by Dr. J. M. Whittaker. The sessions of the meeting for the presentation and discussion of technical papers were held on Wednesday afternoon and throughout Thursday.

Symposium on the Strength of Concrete Structures

ON Wednesday, Thursday and Friday of last week, the Cement and Concrete Association's symposium on the strength of concrete structures was in progress at the Institution of Civil Engineers. Seventeen papers were presented and discussed, several of them being the work of overseas authors. The subjects discussed ranged from the estimation of design loads by probability theory on the one hand, to specific strength tests and analyses, such as an evaluation of the strength of concrete members in combined bending and torsion and of the strength of concrete members under dynamic loading, on the other. Professor A. L. Baker gave a paper reviewing his method of ultimate load design for reinforced concrete frames, and Monsieur Guyon contributed a paper entitled " The Strength of Statically Indeterminate Prestressed Concrete Structures." It was pointed out that the symposium was timely, because both in the United States and in this country, the codes of practice governing reinforced concrete design were being revised. At the last session of the symposium these new design methods were discussed, following the presentation of three papers. One of these papers (by Mr. E. Hognestadt) reviewed American design practice with special reference to the development of design based on ultimate strength by inelastic action ; the second (by Mr. D. D. Matthews) discussed practical applications of the load factor method to the design of reinforced concrete sections, proposed for inclusion in the revised British code of practice C.P.114 ; and the third (by Dr.-Ing. Aas-Jakobsen) compared a method of design based on the principle of superposition and elastic theory, with European and American standard specifications.

Bessemer Centenary

IN co-operation with the Science Museum, South Kensington, the British Iron and Steel Federation is to create a new ferrous metallurgical display in the Museum to commemorate Sir Henry Bessemer. For this purpose, the Federation says, the sum of £50,000 has been allocated. It is hoped the gallery will be completed within three years. Preliminary plans for this exhibition are being prepared in consultation with the Museum authorities. The present space of the iron and steel section is 2800 square feet, but even this is partly intermingled with the exhibits of the non-ferrous metallurgical industries. As part of their general scheme of reorganisation, the Museum authorities hope to make available 3500 to 4000 square feet in a self-contained and separate section. The Minister of Education has expressed his gratitude to the industry for showing its interest in the Museum in so practical a way.

Production Exhibition and Conference

THE second Production Exhibition and Conference was opened at Olympia on Wednesday, May 23rd, by Mr. Iain Macleod, the Minister of Labour and National Service. This exhibition is held every two years to show research and development work directed towards increasing production, and the exhibitors include a number of governmental and other major bodies concerned with the improvement of production in this country. Amongst the bodies represented are the British Productivity Council, the European Productivity Council, the National Industrial Fuel Efficiency Service, the Production Engineering Research Association of Great Britain, the Department of Scientific and Industrial Research, the British Electrical Development Association, the Machine Tool Trades Association, the British Iron and Steel Federation, and the Trades Union Congress. A number of commercial firms are showing their products and an interesting feature of the exhibition is a " progress avenue." In this gallery some two hundred small firms selected by local productivity committees show examples of the ways in which they have increased their productivity. The conference has been organised by the Institution of Production Engineers and during the period of the exhibition, which closes on May 31st, some twenty-six papers will be presented on the main theme, " Investing in Success."

The Study of Technology

THE annual general meeting of the Institution of Mining and Metallurgy was held in London on Thursday of last week. At it, Professor C. W. Dannatt took office as president for the ensuing year, and delivered an address which he entitled " The Study of Technology as a Branch of Education." He introduced the matter by saying that if the Institution was to play its part in educational developments, its members should give consideration to various matters that were important in educational procedures. Subsequently, Professor Dannatt referred to the criticisms of technological education that were made by those who favoured the humanities, criticisms, he said, that took three principal forms. First, he continued, there was the view that the humanities gave a better mental training, but any branch of study could give that training if it was followed with diligence and thoroughness. Secondly, there was the comment that the humanities provided a better understanding of mankind, and so Professor Dannatt said, perhaps they should, but " the proof of the pudding was in the eating," and it would be difficult to maintain that classical scholars were noticeably more successful in human relations than those who studied technology. Thirdly, there was the opinion that the humanities had a broader educational value ; that might be true, Professor Dannatt commented, even though it was open to argument. The fact remained, he continued, that the failings of the over-specialised scientist were no more culpable than those of the over-specialised student of the humanities, and the fault lay not with the subject of study, but with the neglect of matters that should be of interest and were certainly of importance. Whichever view was taken, there could be no justification for belittling the educational value of scientific studies. In another part of his address, Professor Dannatt urged the great importance of English in technological studies. We were all familiar, he said, with technical dictionaries which contained innumerable words that had been adapted or coined to define some specific item or operation, and for which an alternative meaning was seldom allowed. It might be, Professor Dannatt said, that the habitual use of such words led to the assumption that the coining of words was justifiable and that the assumed meaning of a word was always correct.

Royal Aeronautical Society

ON Thursday, May 17th, the president of the Royal Aeronautical Society, Mr. E. T. Jones, presented scrolls of honorary fellowship to Sir Roy Dobson and to Dr. Hugh Dryden, director of the National Advisory Committee for Aeronautics, and several medals, including the Society's gold medal to Sir William Farren. Subsequently Sir William read the forty-fourth Wilbur Wright Lecture, entitled " The Aerodynamic Art," in which he discussed at length the changes in the nature of the flow round an aerofoil in the " transonic speed range," illustrating the phenomena with Schlieren and interferometer pictures. The beneficial effect of vortex generators in preventing a shock wave springing from the point of separation was illustrated. Since it would probably be impossible to avoid separation in all flight conditions, the aircraft would have to be made to withstand the resulting pressure fluctuations. Discussing the time taken to build an aircraft, he suggested that two years might be needed to decide a requirement and agree to a specification, and another two to get the knowledge requisite to undertake detail design. The next three years of drawing and designing might culminate in the first flight. Two to three years of flying would be occupied with investigations and modifications leading to usable aircraft. The lecture was illustrated by a " Shell " film, made at the National Physical Laboratory, in which the phenomena of compressible flow around an aerofoil were rendered visible in brilliant colours.

Performance of 2,000 H.P. Main-Line Diesel-Electric Locomotive

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

No. I

In THE ENGINEER, *October* 2, 1953, *the author commented upon a test bulletin dealing with one of the* 1750 *h.p. diesel-electric locomotives ordered by the former Southern Railway, for main line service between Waterloo and the West of England. In dealing with the larger locomotive No.* 10203, *the test bulletin published by the British Transport Commission interprets the results in terms of time-table planning. In this article the author analyses and comments on the results.*

AT a time when so much thought is being devoted to the eventual replacement of steam power on British Railways by newer forms of traction, it is extremely important to appreciate the operating characteristics of electric, diesel-electric and gas-turbine locomotives in relation to what is being done nowadays by steam. There is a tendency to overrate capacity. In this connection the latest bulletin to be issued by the British Transport Commission dealing with work done under the auspices of the Locomotive Testing Joint Sub-Committee, forms a very valuable work of reference for all who are connected with the allocation of engine power to the working of trains, and of the planning of new schedules.

The programme of tests was a development

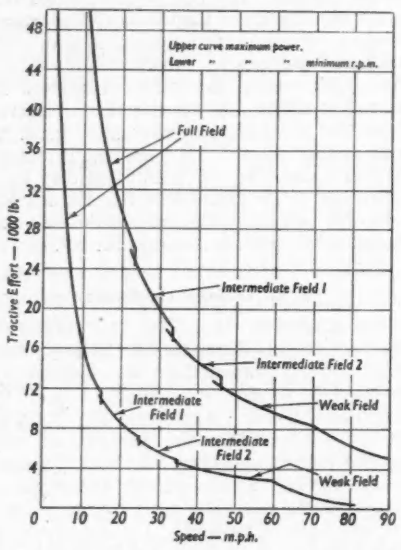


Fig. 1—Designed rail tractive effort characteristics

of that followed with the 1750 h.p. diesel-electric locomotive No. 10202, to which extended reference was made in THE ENGINEER for October 2, 1953. This programme was divided into two parts. The first part consisted of a small number of tests with special trains, at controlled fuel rates, to determine the principal relations of tractive effort, fuel consumption and speed that govern the performance with any load, and govern the efficiency with which mechanical energy is made available for traction. The second part of the tests consisted of a series of runs on revenue-earning express passenger trains. These runs, while wholly observational in character, were made in appreciation of the varying factors in ordinary service that contribute to the commercial cost of energy : the load of the train, the speed, the extent to which a locomotive has to be " opened out," and the physical characteristics of the route. It was felt desirable that the " principal relations," as determined in the first series of tests, should be shown capable of reconciliation with the results obtained under normal service conditions. All the tests, both controlled and service, were carried out on the main line of the Southern Region between Waterloo and Exeter Central. The work was planned and carried out, and the bulletin prepared, by the Swindon Experimental and Locomotive Testing Station, using the Western Region dynamometer car as the testing unit on the road.

THE 2000 H.P. DIESEL-ELECTRIC LOCOMOTIVE

While the general design of the locomotive is similar to that of the 1750 h.p. unit previously discussed, there are certain details of No. 10203 that need particular mention. The total weight in working order is 132·8 tons ; of this 109·5 tons are available for adhesion, while the maximum axle load is 18·6 tons. The designed starting tractive effort at the rail is 50,000 lb, and the continuous rating is 30,000 lb at 19·5 m.p.h. The designed curve of rail tractive effort against speed is shown in Fig. 1. The supplies carried include 1180 gallons of fuel oil, 160 gallons of lubricating oil, 280 gallons of engine cooling water, and 840 gallons of water for train heating.

The power equipment controls are very simple, and consist of but two handles—main power handle and master switch handle. The latter has four positions only, " off," " forward," " engine only " and " reverse " ; the main power handle gives infinitely variable (notchless) power output control. Simplified power and auxiliary circuits are shown diagrammatically in Fig. 2, from which it will be seen that the motors are permanently connected in series-parallel ; there are three groups of two in series, and each group is fed from a separate motor contactor. A fully automatic system of traction motor field diversion is incorporated to enable the available diesel engine output to be used through almost the full speed range of the locomotive. The diversion occurs in three stages, and once it has been introduced it is maintained until the control handle is returned to the " off " position, or until the traction motor current approaches a limiting high value.

In connection with the locomotive itself the basic functions of a torque regulator are discussed in the bulletin, and as this part of the control system has an important relation to the road performance some reference to it, both in theory and operation, is desirable here. The ideal characteristic curve,

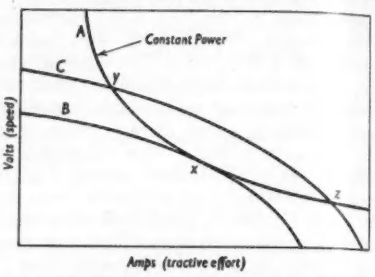
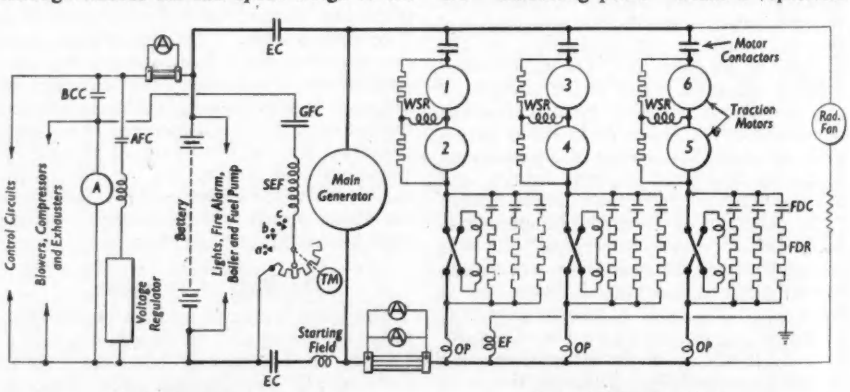


Fig. 3—Typical generator characteristics

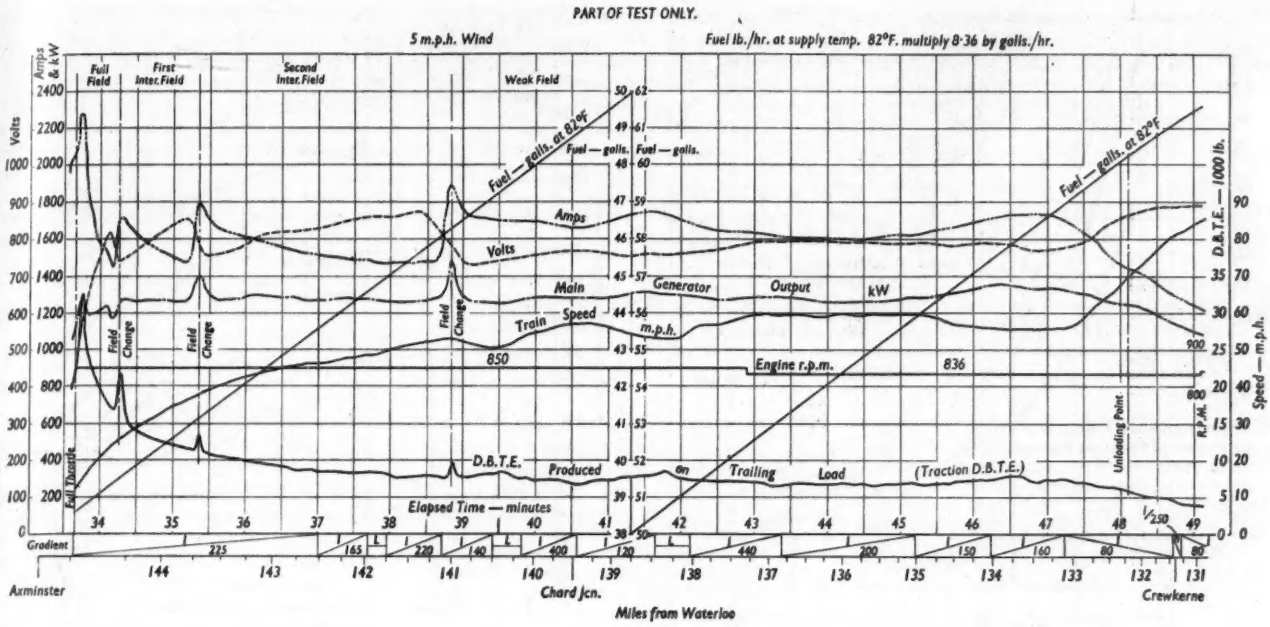
which fully utilises the available output of a prime mover, is a rectangular hyperbola, representing constant power as shown by *A* of Fig. 3. If a generator with this characteristic could readily be built, no further apparatus would be required, and the available output of the prime mover could be utilised at all train speeds. The design of a generator with series, shunt and externally excited windings provides the best approach to the ideal characteristics, but the form of the curve is similar to *B* and *C* of the diagram. Curve *B* utilises the full output at point *x* only, and therefore at only one train speed. At all other speeds the power utilised is less than the maximum available, but in no circumstance is the prime mover overloaded. Curve *C* utilises the full output at points *y* and *z* only ; outputs between these points overload the prime mover, and outputs beyond them underload it.

The function of a torque regulator is to load the prime mover fully along the constant power line between the points *y* and *z*, and to avoid overloading. It is not necessary to use the available output down to zero speed, as this would give an infinitely high starting effort : beyond point *y* the natural characteristic of the generator is followed. Similarly the natural characteristic is followed at high train speeds beyond point *z*. This portion of the curve represents less power than the constant power hyperbola, and arrangements are made to reduce fuel consumption beyond the " unloading point " which *z* represents.



A—Auxiliary generator.
AFC—Auxiliary generator field contactor.
BCC—Battery charging contactor.
EC—Engine starting contactor.
EF—Earth fault relay.
FDC—Field diverting contactor.
FDR—Field diverting resistor.
GFC—Main general field contactor.
OP—Overload protection relay.
SEF—Separately excited field.
TM—Torque control motor.
WSR—Wheel slip relay.
a, b, c—Field diverting contacts on torque regulator.

Fig. 2—Simplified power and auxiliary circuits



Full power. Load 392 tons for twelve vehicles.

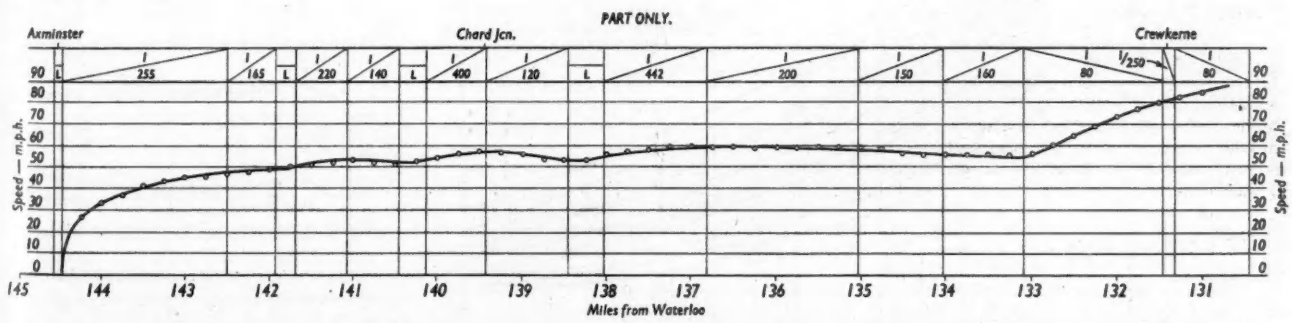
Fig. 4—Example of observations made on a controlled road test

It is, of course, necessary to provide for outputs below the maximum rating of the prime mover, and the control system has to be arranged to select any one of an infinite number of curves within the band of output of the prime mover at the choice of the operator.

The control system of locomotive No. 10203 functions in two stages ; these cover consecutive portions of the power output range. The mechanism consists of pneumatic, mechanical, and hydraulic elements, which are actuated by combinations of the controlled quantities. In the first stage the engine speed is maintained at the nominal idling figure, of 450 r.p.m. over the first sector of movement of the driver's handle. The power output, however, is progressively increased by movement of the handle in the requisite direction. This initiates a sequence of events, by way of a pneumatic-mechanical linkage, which causes a motor-driven resistor to increase the strength of the separately-excited field winding of the main generator. By this means the loading on the engine is increased, thus tending to reduce its speed ; this reacts on the centrifugal governor, which, in turn, moves the fuel racks, by means of an oil-operated servo-mechanism, to increase the fuel injected per stroke until equilibrium of the servo-mechanism is restored. The power output in this stage is very small ; its use is confined to light engine working and yard movements, and it is therefore not representative of normal passenger train duty.

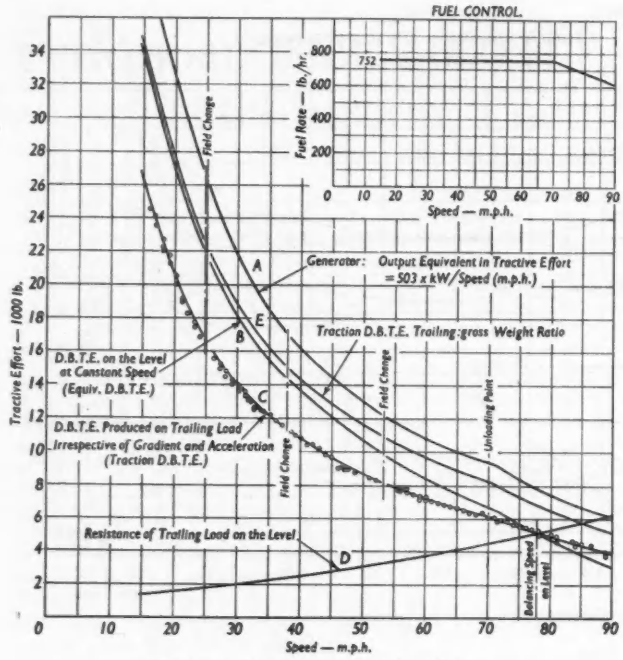
In the second stage, the driver's handle operates over a section in which the revolutions per minute of the engine is increased in such a manner that the maximum output at any given engine speed is obtained between the limits of 450 and 850 r.p.m. The boundary between the two sectors, representing the two stages, is maximum power output at minimum engine revolutions per minute, and corresponds to the position where the operating linkage has just engaged the stop on the speed setting linkage of the governor. This member is inoperative in the first stage. Further movement of the handle causes the same sequence of events as in the first stage ; in addition, however, the stop on the linkage rotates the governor member, and this changes the position of a fulcrum, altering the governor setting and consequently the engine revolutions per minute. If the track conditions are such that the engine is still not fully loaded even with the generator field excitation at its maximum, the motor-driven resistor arm continues to rotate in the "increase excitation" direction, closing contacts which connect the first stage diverting resistors across the traction motor fields. This causes the motors to take a higher current and lower voltage for a given train speed, enabling the torque regulator to load the engine still further. This increases the train-speed range over which the available engine power can be utilised. If the engine is still not fully loaded, the arm rotates further, closing contacts which in turn bring into effect stages 2 and 3 of field diversion. When the controller handle is moved to its maximum position the stop is engaged by the pneumatic portion of the linkage and the engine speed and torque—and therefore power—are all at their maximum values.

Thus the control system permits the driver to select any required power output from the engine-generator unit. If, for instance, a rising gradient is encountered and the controller handle remains unchanged, the generator loading increases above the preset value, causing a tendency for the engine speed to fall and operate the governor. This operates the motor-driven resistor in such a direction as to weaken the separately-excited field of the main generator, so decreasing the load on the engine. The speed of the engine tends to rise until equilibrium is restored by the governor. While these changes are taking place the engine temporarily receives more fuel, but at the end of the change the engine output has been restored to its original value, so that the only permanent change is in the value of the



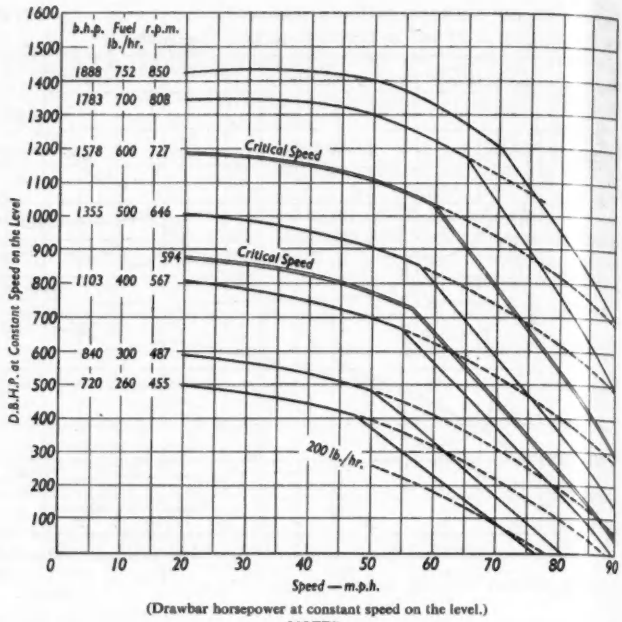
The above shows the speed-distance curve calculated from Curves *C* and *D*, Fig. 6, compared with the actual speed (shown thus : -o-) attained on the test as given in Fig. 4.

Fig. 5—Example of proving the drawbar and resistance characteristics of a controlled road test



Full power. Load 392 tons for twelve vehicles.

Fig. 6—Example of an analysis of a controlled road test



(Drawbar horsepower at constant speed on the level.)

NOTES :

(1) Condition after 106,000 miles, 2865 engine hours.
(2) Top full line—maximum power, maximum engine revolutions per minute. Bottom full line—maximum power, minimum engine revolutions per minute. For lighter duties, power is available, at minimum engine revolutions per minute, below that shown by bottom full line.
(3) Powers between top and bottom full lines are infinitely variable by movement of controller, but the engine is automatically prevented from working at the two critical speeds shown.
(4) Temporary fluctuations of power at the field changes have been disregarded in this diagram.
(5) Full lines are lines of constant controller position, fuel rate, brake horsepower and revolutions per minute up to the unloading point. From this point the lower branch represents the same revolutions per minute with reducing fuel rate and power, controller position unchanged; the upper branch (dotted) represents the continuation of the constant power and fuel rate which may be obtained by changing the controller position to increase revolutions per minute.
(6) Brake horsepower and fuel rate are inclusive of all auxiliaries except train heating.

Fig. 7—Equivalent drawbar horsepower characteristics

excitation of the separately-excited field. The engine-generator unit, of course, is operating at a point lower down on the selected characteristic curve after the change. When the generator load decreases, the sequence of events occurs in the opposite direction and the engine-generator unit moves to a higher point on the characteristic curve.

The Controlled Road Tests

It was considered that the principal relations could be satisfactorily established by the running of controlled road tests in four conditions of loading, as follows.

The actual results recorded in the dynamometer car on one such test, at full power, are shown in Fig. 4 ; the exact load was 392 tons trailing, and the location was a stretch of 14 miles between Axminster and Crewkerne, in the course of a run from Exeter to Waterloo.

The bulletin explains at some length the very great care now taken to reconcile test results obtained with the theoretical considerations involved, and the diagrams reproduced herewith in Figs. 5 and 6 provide examples of the analyses now undertaken of test results before the principal relations of the locomotive are taken as finally established. In Fig. 6 all values of drawbar tractive effort, irrespective of gradient and acceleration, are plotted, and the curve *C* is drawn through the scatter of the points. They relate to the entire run of 170 miles from Exeter to Waterloo and not merely to the 14-mile stretch shown in Fig. 4. When it is stated that all values are plotted, this remark should be qualified, in that values taken at points where the gradient is changing are excluded. From curve *C*, around which the recorded points lie closely, curve *B* is deduced from reference to the gradients on

Engine r.p.m.	Per cent of max. b.h.p.	Approx. trailing load, tons,	Per cent trailing load to gross load
850	full	400	75
700	81	290	69
560	56	130	50
430	38	60	32

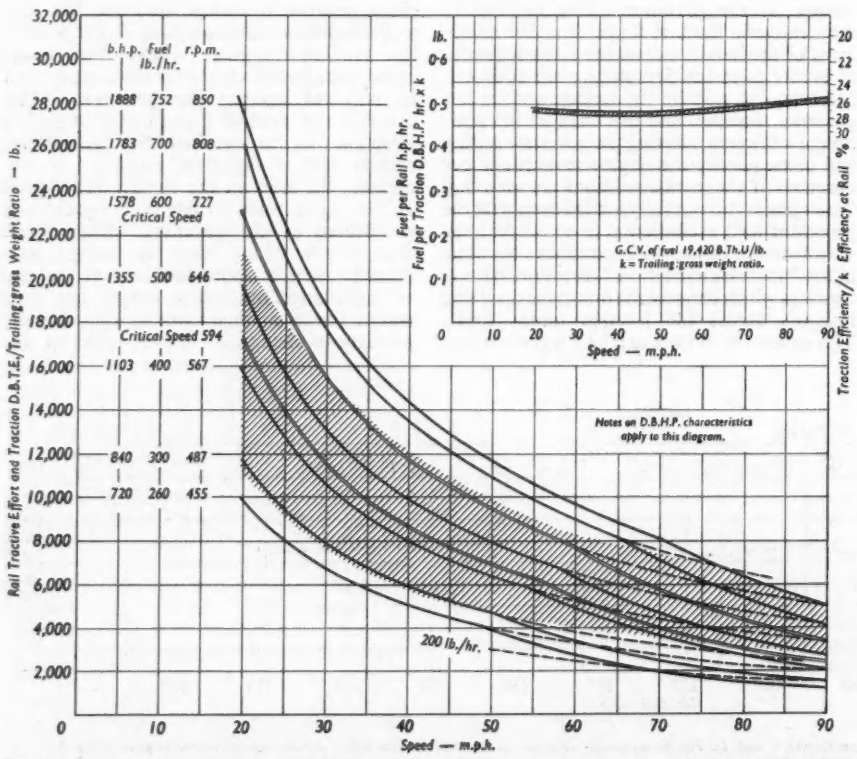

b.h.p. Fuel r.p.m. lb./hr.
1888 752 850
1783 700 808
1578 600 727
Critical Speed
1355 500 646
Critical Speed 594
1103 400 567
840 300 487
720 260 455
200 lb./hr.
Notes on D.B.H.P. characteristics apply to this diagram.
Rail Tractive Effort and Traction D.B.T.E./Trailing:gross Weight Ratio — lb.
Speed — m.p.h.
Fuel per Rail h.p. hr. / Fuel per Traction D.B.H.P. hr. x k
G.C.V. of fuel 19,420 B.Th.U/lb.
k = Trailing:gross weight ratio.
Traction Efficiency/k. Efficiency at Rail %

Fig. 8—Characteristics of traction drawbar tractive effort/trailing : gross weight ratio and of rail tractive effort

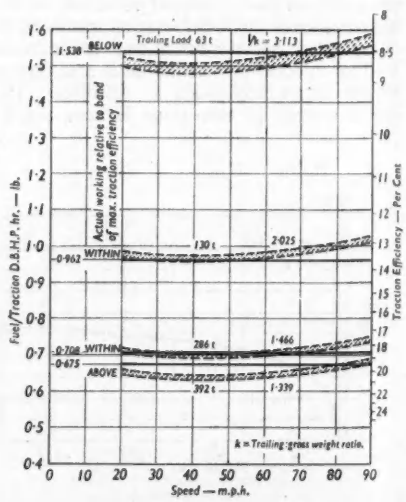


Fig. 9—Showing the predominating influence of the trailing : gross weight ratio on traction efficiency

which the readings for curve *B* were recorded; in addition curve *E* is obtained by scaling up curve *C*, in the ratio of the gross load to the trailing load behind the locomotive. This latter curve, *E*, can then be compared with the generator output equivalent in terms of tractive effort, as represented by curve *A*.

From the viewpoint of train timing the curves *B*, *C* and *D* are of great importance, and it was considered essential that the values as found, and presented in Fig. 5,

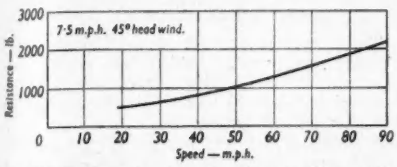


Fig. 10—Total wind and track resistance of locomotive

should be subjected to a further cross-check. The result of this is shown in Fig. 6. From curves *C* and *D*, therefore, was plotted the speed distance curve that could be expected from a start at Axminster, going east; the actual graph recorded in the dynamometer car is indicated in Fig. 6 by the series of small circles plotted at every quarter of a mile, and the two curves, it can be seen at once, coincide almost precisely. From this it is evident that the basic curves *C* and *D* in Fig. 5 can be accepted as reliable, and the fuel and power relations were duly based upon them.

The equivalent drawbar horsepower characteristics are shown in Fig. 7, and the very wide range of power output over which the tractive efficiency at the rail is practically at a maximum is brought out by the further diagram, Fig. 8. At the same time it is important to appreciate the predominating influence of the trailing to gross weight ratio upon the overall tractive efficiency, and this characteristic is shown graphically in Fig. 9, covering the four loadings used in the controlled road tests. Here one might interpolate that although loads of less than 200 tons are unlikely in modern express passenger traffic there are many train schedules that make a very modest demand upon engine power, and would, with diesel-electric locomotives, require similar conditions of working to those involved with the 130-ton loads of controlled road tests. Details of some actual running with this locomotive in ordinary service on the same route, to be discussed in the second instalment of this article, emphasise this point.

Before leaving the controlled road tests the values obtained for specific resistance of the coaching stock and the resistance of the locomotive are worth mention. These are plotted in the graphs, Figs. 10 and 11. The

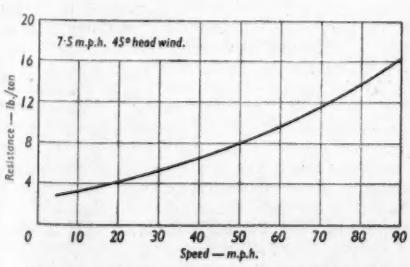


Fig. 11—Specific resistance of coaching stock

value for coaching stock is given in conditions of a 7½ m.p.h. head wind blowing at 45 deg. to the line of railway, and the drawbar characteristics are based on such conditions. Obviously, schedules must be planned to include a margin of power for dealing with a moderate adverse wind. It is interesting to observe, however, that the same graph of specific resistance would, with this particular unit, apply to the locomotive itself also. The specific resistances of the stock at 60 m.p.h. and 80 m.p.h. are 10 lb and 14 lb per ton, respectively; for a load of 133 tons these become totals of 1330 and 1860—almost exactly the values for locomotive No. 10203, as shown in Fig. 10.

(To be concluded)

Supersonic Flight

(No. II—*Concluded from page* 516, *May* 18*th*)

On May 9th, the Royal Aeronautical Society held a series of section lectures and discussions on the subject of supersonic flight. Papers were read on Aerodynamics, Propulsion, Structures, and Control and Allied Problems. We abstract part of the proceedings.

Control and Allied Problems

MR. H. H. GARDNER commenced by emphasising the desirability of the "weapons system" approach, and outlined the questions that should be posed before a system was chosen. On the subject of aircraft guidance, he observed that, as speeds increased, the margin of error became very small, and this might necessitate the use of a system which was more rapid in evaluating the given situation than the human brain. This was particularly true if a high degree of accuracy was required as, for instance, for navigation in a congested air lane, for high-altitude bombing, or for the interception of supersonic bombers. The remedy for such a situation, where the pilot's reactions are considered too slow, would be to provide the aircraft with some form of automatic guidance which fed information directly into the control system of the aircraft.

As the aircraft became more and more an integral part of the weapon system it was believed that automatic guidance would be required and it might well be asked whether, in these circumstances, the pilot was a necessary addition to the aircraft system. He suggested that, although pilots could make mistakes, they were much less likely to go completely wrong than automatic systems. He believed that the crew would be retained until the last stage of development as they were always available to monitor the functioning of the automatic systems, and in the event of failure or some unforeseen happening, they could always take over and deal with the emergency.

Dealing with the need for integrated guidance and control of aircraft, Mr. Gardner continued:

To start with, I will briefly describe a typical World War II system of defence using all-weather fighters. In this system, the hostile aircraft was first detected by early warning radar. When the hostile aircraft and the defending fighter were within range of a ground control interception radar equipment, the positions of both the aircraft were presented on one display to a human operator. This human operator, the controller, then attempted to steer the fighter into a stern chase. This was achieved by the controller observing the relative positions of hostile aircraft and fighter, judging the corrections to be made, and giving the pilot of the fighter verbal vectoring instructions over the R.T. When the fighter was sufficiently close behind the hostile aircraft, its own airborne interception radar equipment would search for the hostile aircraft, and provide a more accurate measure of its position. This position was displayed to the observer in the fighter, who would give vectoring instructions to the pilot. The fighter would be flown up behind the hostile aircraft until the range was close enough for the pilot to see it. The pilot would then aim his aircraft visually and fire his guns.

This type of system was reasonably effective: if the number of hostile aircraft present was not so high as to saturate the defensive system, something like 10 per cent of the hostile aircraft were destroyed. However, each interception took a fair amount of time.

Such a system will be of no use in the future. The destructive power of bombers is now so great that virtually all hostile aircraft must be destroyed, and, what is more, they must be destroyed before they cross the coast. Further, the great speed of supersonic bombers, and of supersonic fighters intercepting them, together with the difficulty of obtaining any major increases in the range of E.W. radar, result in the time available for the interception system being incredibly short. This demonstrates the need of collision course interceptions, in which the time is saved by the fighter not having to make a tight turn and settle down in a stern chase. It is thus obvious that the high degree of precision required to destroy the maximum number of hostile aircraft, the short time available, and the additional complexity of computing collision courses, result in the need for a complex automatic system for guiding the fighter towards the hostile aircraft.

We now look at such a hypothetical system of defence using supersonic fighters. Such a defensive system would be designed on the weapon system concept, in which the fighter aircraft, its missile armament, the ground radar equipment, &c., are all conceived as interlinked elements of one coherent system. The weapon system concept is of tremendous importance, as it would appear to be the only satisfactory way in which such complex systems as that being described can be successfully developed.

The fighter would be directed towards the hostile aircraft by means of a guidance system using target information obtained from the G.C.I. radar. This guidance system might take a number of forms. For instance, both hostile aircraft and fighter might be tracked by ground radar, and the steering instructions computed on the ground and fed into the fighter autopilot via a radio link: this is identical with the system of command guidance used in some missiles, and is an automatic version of the World War II system of G.C.I. control. Alternatively, the fighter might be equipped with the same type of receiving equipment as in a beam riding missile, and would then automatically ride down the beam of a ground radar which was tracking the hostile aircraft.

When the fighter was sufficiently close to the hostile aircraft, its A.I. set would search for the hostile aircraft and lock-on to it, tracking it continuously. The data from the A.I. might then be used to home the fighter automatically in a similar manner to a radar homing missile. With suitable choice of the parameters in the homing system, the fighter could be made to fly on a collision course. The A.I. data would also be used to compute the point of launch of the missile armament, and to initiate the automatic launching sequence. The break-away manœuvre after launching might also be done automatically.

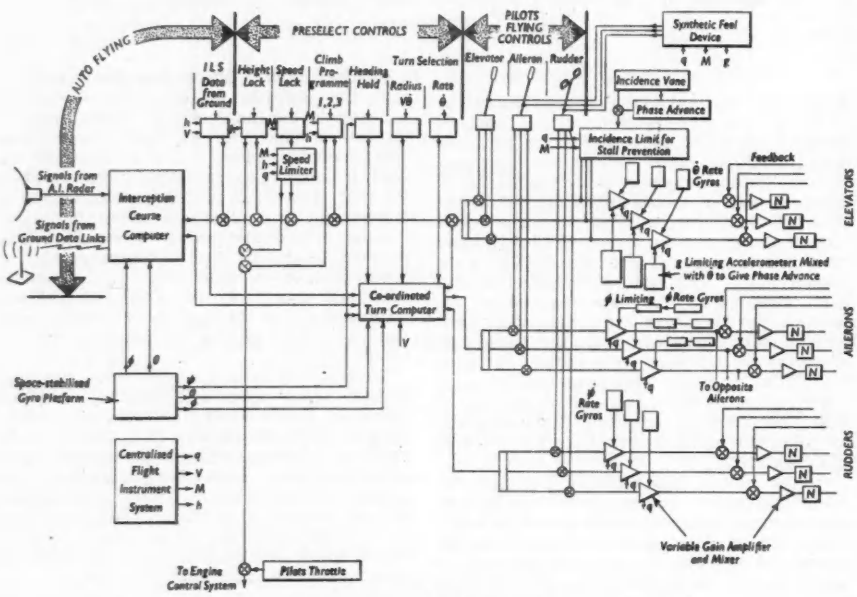
We thus see that the supersonic fighter would not be functionally very different from a surface-to-air guided missile. The crew would be retained to monitor the functioning of the system, to take charge in case of malfunctioning of equipment, and to distinguish the correct target on the A.I. display in the presence of various forms of clutter, such as "window" dispensed by the hostile aircraft.

In addition, the following facilities internal to the aircraft may also be required. In order to bring the aeroplane to its operating speed and altitude in the most economical manner a complicated climb technique is required, and there is no reason why this should not be programmed in the aircraft system. The pilot would select, for example, climb procedure to reach height in minimum time; or alternatively, to reach height

for the minimum use of fuel. The climb would then be executed without any further attention from the pilot.

In order to aid navigation and to help the ground controller during recovery it may be necessary to provide facilities for selection of rate of turn, or radius of return, and also for heading hold. Automatic speed lock and height lock will also probably be demanded. For structural and physiological reasons "G" limiting should be introduced. For stability reasons and in order to prevent various airborne gyroscopes from toppling, roll rate limiting may be needed.

The illustration shows an elementary functional



Control system for an interceptor

diagram for such an intricate system.

Now a control system such as we have described is really a most formidable undertaking, far more complicated than a guided weapon system. Reliability considerations will almost certainly demand duplication, triplication, and perhaps even quadruplication of certain components. We will almost certainly be forced to the use of a primary electrical signalling system. In case of failure, reversion, perhaps to a manual system, might be employed.

Conclusions.—The general conclusions which emerge may be summarised as follows :—

(1) Problems associated with the control of an aeroplane or missile would appear to have a far greater rate of increase than those arising from the more established aeronautical components.

(2) A missile or a military aeroplane is now no longer a separate entity and therefore must be considered and designed as an integral part of the complete weapon system.

(3) Missile and aircraft design for supersonic flight will become more and more specialised in their application. The task of the pilot will change continuously as automatic means of control are developed.

Discussion

A contributor observed that supersonic aeroplanes would be subjected to thermal as well as load stresses. For some time the Americans had been measuring structural stretches on a big scale on their comparatively simple subsonic aeroplanes, and the teams which they employed even on this work were far bigger than any we had in this country. Moreover, on the aerodynamics side we were entering new stability problems, creating all sorts of derivatives which no one had worried about before, and also raising the problems of inertia. Workers in the field were asked to provide all this necessary information on these subjects so that the aircraft could be subject to automatic control for at least part of the flight. This meant that they had not only not jump to conclusions. There was therefore no reason to suppose that our flight testing programmes could be or should be any smaller than the sort of work going on and growing up in the United States.

In view of the limited technical effort obviously available in this country, if individual firms, as they neared completion of a prototype, attempted to build up vast flight test groups—which would be needed for this proving—with probably little experience for six or eight years previously, there would be a great waste of effort. Even if the whole flight test team of the R.A.E. or Boscombe Down were put on a simple job of this kind they would only begin to approach the effort available and, politically, it was fairly clear that at present such an arrangement could not work.

The time was fast approaching when we must view the flight testing of these advanced aircraft in the same way as we had viewed the advanced tunnel testing ; there must be a co-operative effort. Either the Ministry establishments must devote a much bigger effort to providing a test team and test facilities to cope with these problems in a reasonable time and provide the necessary instrumentation and experience, or else the industry must get together in the same way as with the transonic tunnel and provide a central flight test unit which could collect together people with a continuing experience to do the job and the necessary equipment. If this were not done we should spend twice as long proving our aeroplanes and finding out how safe they were as we spent in designing them.

Another speaker made a plea for the place of the research aircraft in this work. A disparaging comment had been made on research aircraft which ought to be answered. The problem, collectively, was to make the best integrated solution to satisfy all the requirements which had been mentioned during the day. One way of doing this was by good project studies and another was to build an aeroplane. It cost from one-third to one-tenth the price of the corresponding military aircraft and the results could be as valuable and obtained more quickly than those from a military aircraft exercise done at the same time. A good example of this was the Fairey "Delta." (The F.D.2.)

The chairman held the view that supersonic civil aircraft were not very far away. We were, in fact, on the threshold of an extremely interesting period in the civil aircraft world as well as in the military aircraft world.

British Short-Circuit Testing Facilities

THE council of the Association of Short-Circuit Testing Authorities (ASTA) has decided (by agreement with the Director of Scientific and Industrial Research) to extend the facilities for the short-circuit testing of electrical apparatus permissible under the agreement between the ASTA and the National Physical Laboratory from 11kV, 250MVA, up to 33kV, 750MVA.

It will be recalled that the first short-circuit testing station was opened in 1929 and was followed by others. They were set up at that time primarily for research and development, but as experience was gained the need for a British Standard specifying conditions of testing became clear. Co-operation between the testing stations led to the formulation of a British Standard for Oil Circuit-Breakers, B.S. 116 : 1937, which also formed the basis of an internationally recognised standard specification I.E.C. No. 56 : 1937.

Having achieved a standard to which testing could be undertaken, the need for a common interpretation of the standard and uniformity of testing procedure was realised. This was an important contributory factor to the formation of ASTA in 1938. When the Association was formed its membership was confined to those companies which had short-circuit testing stations in operation. But other switchgear manufacturers in Great Britain, knowing the need to prove circuit breakers under short-circuit conditions, approached the Department of Scientific and Industrial Research with a request for the setting up of a national testing station.

Because of the national need for such testing facilities ASTA members indicated to the D.S.I.R. they would be prepared to operate a joint scheme to provide short-circuit testing facilities at their stations up to a limit of 11kV and 250MVA, continuing a procedure which they had followed individually for some years. The limit proposed was intended to provide testing facilities for non-members of ASTA covering the bulk of the requirements of supply undertakings for certified distribution gear, and as such was welcomed by the supply undertakings and British switchgear manufacturers. By agreement with the D.S.I.R. the joint scheme was inaugurated making these facilities available to supply authorities and British manufacturers. The National Physical Laboratory undertook to appoint an observer at each testing station, who would witness all certification tests carried out, and satisfy himself that the conditions complied with the appropriate standard or the Association's agreed rules.

Since 1938 distribution voltages and MVA ratings have increased considerably with the result that British manufacturers without testing stations of their own have had perforce to send their gear above 11kV and 250MVA to a foreign station for testing and certification.

To reduce foreign certification to a minimum the Association has therefore decided to increase the range of testing for certification for non-members up to 33kV and 750MVA. But the running costs and capital charges of the testing stations have increased considerably during recent years and, hence, existing fees are not economic. On the other hand, it was realised if British manufacturers without testing stations were to be encouraged in the national interest to come to the ASTA for certification tests then the charges had to be reasonably comparable with the fees and expenses of alternative tests made, for example, at the K.E.M.A. in Holland, which is State-subsidised.

Accordingly, it was decided to base the charges to non-members on the normal tariff applying to members.

Future Developments in Steelmaking

By H. H. BURTON, D.Met., F.I.M.

In the presidential address which he delivered to the Iron and Steel Institute on May 16th, Dr. Burton surveyed some of the problems and progress in steel manufacture and metallurgy. In that survey he discussed some of the likely requirements in methods and plant if steel makers are to meet the needs of engineering in the immediate future. Extracts from that part of the address are given here.

IN an endeavour to be strictly impartial, the first question to be considered is whether the steel age is already showing signs of passing and is destined soon to be replaced by the age of some other metal, such as the much publicised titanium, which is regarded by some enthusiastic metallurgists as the next on the list. Though I hold strong views on this subject, which I may ventilate some other time, they would take too long to discuss now and I shall assume, on what I hope are sufficient grounds, that steel manufacture will not decline but will rather expand within the lifetime of anyone here present, and I shall pass on to make some suggestions for future progress within the steel manufacturing industry.

Dealing with the processes in the order of manufacture, the first is steelmaking. At once, the question arises whether the open-hearth process, by which the great bulk of the world's output is made to-day, will remain pre-eminent in the future. The answer depends, I think, largely upon the type of steel to be made and the purpose for which it is to be used. Mr. Mitchell concluded, in his address (to the Institute) in 1953 that, in basic steelmaking, the Bessemer and the open-hearth processes represented the most logical practice for charges employing pig irons having phosphorus contents over 1·7 per cent and below 0·5 per cent, respectively. The answer may be quite different, however, for special and alloy steels, for which the acid open-hearth process is still largely used in this country, especially for large forgings. Though this process is less used abroad than in Great Britain, it is understood that there has been some reversion to acid steel for making forging ingots in the U.S.A.

There are many advocates of the large-scale basic electric furnace as the logical substitute for acid open-hearth, even for large forging ingots, one of the strongest arguments being the possibility of refining in this way materials which would be unsuitable for the acid open-hearth process on account of high sulphur and phosphorus contents. On the other hand, contrary arguments could be advanced, such as the generally lower hydrogen content of acid open-hearth steel and the definite (though not fully explained) superiority of this steel in fatigue properties, in creep resistance at moderately high temperatures, and in lower susceptibility to overheating. There is considerable evidence on all these three points and, particularly outstanding is that brought out by Professor Preece in his researches on overheating, which showed, in some cases, a difference of as much as 150 deg. Cent. in what was termed, " the incipient overheating temperature " of steels of similar chemical composition but made by the basic electric and acid open-hearth processes, respectively. This confirmed the experience of many drop forgers and users of drop forgings, who were troubled with overheating, especially of aircraft components, during the war. On the basis of this, and other evidence, I believe that the acid open-hearth process is likely to continue for the manufacture of many special and alloy steels and, particularly, large forgings.

These arguments, so far, relate to the metallurgical aspects of the two processes, but from the practical side there is also the problem of the power requirements involved in a large-scale change from open-hearth to electric melting. Unless the available power in this country can be greatly increased in the not distant future (perhaps through atomic energy stations) it is difficult to see where the additional supplies would come from.

Ingot Making

Whatever melting process is employed, the problem of making satisfactory ingots will remain, and this is one of the stages in the manufacture of special steel, which, in my view, requires the most attention. Unless the ingot is satisfactory in the first place there is little hope of producing a first-class finished product, whether in the form of billet, bar, drop forging, or a forging of the largest size. Referring again to Mr. Mitchell's address, he asked " whether it was too much to expect that the vacuum process might yet be applied to the ladle or in the mould." Since then the Bochum vacuum casting process has been announced and has created widespread interest, though as yet its capabilities are not fully known here. From published literature it seems that steel cast by this process contains much less in the way of both gases and non-metallic impurities than steel cast in the normal way in air, but it is understood that segregation found in ingots cast *in vacuo* is similar to that with which we are familiar. It appears, therefore, that we must look even further ahead than vacuum casting for a solution to the problem of segregation.

Other important factors affecting the casting of ingots which are receiving, and must continue to receive, close attention are the refractories employed for nozzles and runner bricks, the design and construction of feeder heads, and last, but by no means least, the design and construction of the largest ingot moulds. Those who have the responsibility of making large ingots—and it is a great and at the same time fascinating responsibility—must have experienced cases where moulds have cracked from top to bottom during the casting of the first ingot. This means a substantial loss financially, but in many cases an even more serious delay in the manufacture of some forging or series of forgings, for which the ingot was designed. One must sympathise with the mould manufacturer, who has doubtless done his utmost to produce a first-class article, but results to date are disappointing and probably what is needed most is some entirely new and bold revolution in mould design, rather than improvement in the properties of cast iron, which has received so much attention hitherto. At present some very large ingot moulds are being built up from segments and clamped together by one of several methods, the object being to reduce the stresses below those which would develop in a one-piece mould of the same size, but the new system is complicated, both in manufacture and in the method of clamping the segments together.

Many of the largest ingots made nowadays are intended for the manufacture of hollow forgings, such as seamless boiler drums, chemical reaction vessels, and so on. Hitherto such ingots have been annealed, parted, and trepanned to accommodate the forging mandrel, and ingots of 270 tons in weight have been made and utilised in this way in Great Britain. Obvious advantages, however, would result if ingots intended for such purposes could be cast hollow in the first place, thus eliminating the need for trepanning and, in many cases, enabling the cast cylinder to be stripped whilst still hot and charged immediately into forge reheating furnaces.

Hot Working

To deal adequately with the hot working stage of manufacture would require much more time than is available, but some urgent needs include larger plant, in the way of presses and rolling mills, to meet the demand for products of larger size ; development of plant suitable for special shapes, such as are often termed " closed-die " forgings ; and the type of forge reheating furnaces designed to ensure the greatest uniformity in temperature in the shortest time which has been found to be consistent with safety.

Taking the last point first, and purely on the basis of ease in obtaining accuracy and uniformity in temperature, a good case could be put forward for electrically heated forge furnaces, but I doubt whether they will find general favour in the near future on account of high cost, insufficient power supplies, and difficulty of providing heating elements for regular use at temperatures of the order of 1200 deg. to 1250 deg. Cent. If some or all of these handicaps can be overcome the electric reheating furnace may well find application in the forge, especially in cases where the permissible range in forging temperature is narrow. Experience leads, however, to the conclusion that, for most reheating operations, gas-fired furnaces are likely to hold the field for some time to come.

The need for and the design of improved forging plant in this country are matters which are receiving the closest attention. Great Britain produces some of the world's largest forgings, yet the largest forging press in this country is one of 7000 tons, whilst in various countries abroad there are presses ranging from 10,000 to 15,000 tons capacity, some of which are capable of dealing with forgings of larger sizes than have yet been made.

Apart from mere size, however, there is an increasing need for plant to manufacture special shapes, and this is likely to include presses designed to work in more than one plane simultaneously. An extremely ingenious development of this kind is the system designed in France by Roederer, primarily with the object of producing crankshafts too large for drop forging, but having the same desirable characteristics in the way of what is termed, in this country, " continuous grain flow " and in France, " fibrage intégrale."

The term " forging in the machine shop " has been applied to cases where a forging leaves the hammer or press with a comparatively simple shape and receives a large amount of further shaping during machining. There are many cases of forgings where such extensive shaping can hardly be done by any other means : for example, a so-called " gashed type " rotor for a steam turbine, in which adjacent discs, or wheels, are so

close together that it is impracticable to form them under the press by any kind of forging tool. There are other cases, however, where forging to something like the required shape results in a substantially better product.

Heat-Treatment

In alloy steel manufacture, there is no more important stage than correct heat treatment, yet it is often given less attention, both in the design and layout of plant and during practical operation, than other stages which are more easily controlled. One reason for this is that many plant and production engineers—perhaps unconsciously—tend to regard heat-treatment, especially at an intermediate stage, as something of a nuisance, devised by metallurgists for mysterious ends and liable to interrupt the otherwise smooth flow of the product through the plant. As a result of this, there have been frequent bottlenecks in production due to insufficient heat treatment capacity to deal with the full output of the forges or rolling mills and, equally serious, many cases of defects such as hairline cracks, caused by long delays between the hot working and heat-treatment operations. Where furnaces are fired by raw producer gas, further delays and, hence, bottlenecks have resulted from the necessity to " burn out " at the weekend and thus often to prolong the heat-treatment cycles required for large products. If these two difficulties are to be overcome, new plant should provide, on the one hand, for greater heat-treatment capacity in relation to the earlier stages of manufacture, and, on the other, types of producers operating on one of the clean gas systems which are already developed, or in process of development.

In considering future improvements, both in plant and processes, it is necessary to distinguish between intermediate heat-treatments, by which is meant those following immediately after hot working, and final heat-treatment for ensuring the mechanical properties required in the finished product.

In most existing plants, the precautionary treatment for rolled products, such as billets, large bars, and even some types of drop forgings, consists of slow cooling in a pit furnace, which may be preheated by gas, but, in the majority of cases, relies upon the slow cooling rate of the material in the pit to prevent such defects as hairline cracks, clinks, and so on. On the other hand, forgings (especially alloy steel forgings) are usually charged immediately into a suitable furnace and subjected not only to slow cooling, but to a carefully designed heat-treatment cycle.

Whilst pit cooling may often achieve the desired results, it has a number of disadvantages, including the time taken to fill the pit, and the consequent differences in temperature between products charged early and late before the pit is closed, and the large amount of floor space necessary to provide pits adequate for a substantial output. Furthermore, pit-cooled bars, for example, often show appreciable difference in hardness and, unless charging and stacking are carried out with great care, they are apt to be bent and to require subsequent straightening before final heat-treatment.

Though more expensive in the first place than a series of cooling pits, a most desirable future development would be the installation of continuous or semi-continuous heat-treatment plants, into which the hot products would be charged and would undergo a cycle of heat-treatment. The advantages of this system would be : clinks and hairline cracks would be eliminated ; the product would be much more uniform, both in structure and hardness, and in the form of billets and large bars; the product would be kept straight.

For large products, continuous furnaces are less suitable and a major improvement which is visualised is in furnace design, to ensure greater uniformity in temperature from roof to furnace hearth or furnace bogie. It would be an advantage to have furnaces with better insulation, but lower heat capacity, than is normally met with to enable the furnace to be cooled down more rapidly between high-temperature and low-temperature portions of the cycle.

In the heat-treatment of large forgings, it is always difficult to decide whether furnaces required largely for intermediate heat-treatments should accommodate several forgings simultaneously, or should be of smaller type intended for one forging only. Both systems have their merits for particular products, but in dealing with some of the more difficult forgings, such as generator and alternator rotors, there is much to be said for the installation of several units of the single type, thus enabling a specialised heat-treatment cycle to be applied to a particular forging without holding up the furnace until other forgings are ready to be charged. One danger associated with this latter practice arises from the natural desire of those in charge of the heat-treatment plant to " get on with the job " after the last forging is charged, without waiting for the necessary uniformity to be obtained throughout the furnace. Many cases of hairline cracks have been traced to the inadequate time allowed for the later forgings to be cooled through the transformation range before reheating for the next stage.

For final heat-treatment, which determines the mechanical properties of the finished product, improvements are highly desirable in furnace design, in pyrometric control and, perhaps most of all, in the quality of the furnace operators, especially when dealing with products of large size.

For the heat-treatment of bars, which in this country is carried out largely in batch type furnaces, continuous furnaces would have many advantages. What is visualised is continuous heating of the bars in a conveyor type furnace, followed by quenching for a predetermined time in oil, and followed again by a conveyor type furnace for tempering. Such an arrangement would presuppose that the bars passing through at any given time were sufficiently similar in size and composition to be subjected to a standard hardening and tempering treatment, which is quite feasible for a number of the steels specified to be heat-treated to, say 55 to 65 or 45 to 55 tons per square inch. This method would have the following advantages over batch type heat-treatment :—superior straightness ; much greater freedom from cracking, which often occurs through too long immersion in the quenching bath, and greater uniformity in mechanical properties, since " slack " quenching would be avoided and all bars would receive exactly similar heat-treatment.

As stated earlier, the plant required for large forgings is completely different, and the most essential features are uniformity of furnace temperature, both in the heating and soaking stages, and the correct application of pyrometric control to ensure uniformity in all parts of the forging before it is withdrawn from the furnace, whether for hardening or tempering. Furnaces used for the heat-treatment of large forgings are not usually provided with means of heating in the hearth, which is difficult for obvious reasons in a bogie furnace. Temperature records of many forgings heat-treated in such furnaces show conclusively that it is almost impossible to attain the same temperature, say, at the upper and lower portions of the body of a rotor forging, as placed in the furnace, however long the soaking period employed. One remedy is to turn over the forging through 180 deg. some time before it is withdrawn from the furnace and, as it is difficult to devise automatic rotating gear which will stand up to long usage, this is the method normally adopted. Furnaces equipped with atmosphere circulation do show substantial advantages over those not so fitted, but, since some steels regularly used for rotor forgings are very sensitive to variations in heat-treatment temperatures, there is still room for improvement. An alternative is vertical heating, employing electric furnaces of cylindrical shape, but vertical heat-treatment involves difficulties in the method of holding the forging in the furnace, which may be either by suspension from gear which passes through the furnace roof, or by resting the bottom end of the forging on some form of " stool." The second method has the great disadvantage that, unless care is taken that the stool itself is heated to the same temperature as the forging, the lower end of the latter is apt to be cooler than the remainder. Where the object to be heated is in the form of a hollow cylinder, such as a chemical reaction vessel, vertical heat-treatment has great advantages over horizontal, but for some large solid objects horizontal heating may offer advantages, provided that adequate uniformity is attained and the method of support on the furnace hearth or bogie is properly designed.

There are two further most important requirements in heat-treatment, especially of large forgings : the first is the supervision of the operations by really skilled and experienced individuals, and the second is more intelligent use of pyrometric control. It is an unfortunate, but perhaps a natural, consequence of the increased application of pyrometric instruments that the skill of furnace operators, in judging both temperatures and uniformity in temperature, has become a neglected art. I believe that no pyrometer equipment, however elaborate and accurate, is a complete substitute for human observation and intelligence. Most of us must have experienced cases where, according to the recorder chart, the thermal history of a forging has been excellent yet, as shown by subsequent mechanical tests, the forging is anything but uniform and micro-sections taken from test pieces reveal non-uniformity in structure corresponding to temperature differences of as much as 50 deg. to 100 deg. Cent. Such cases could never occur if not only the temperature recorder but also the appearance of the forgings in the furnace were observed by those responsible. A pyrometer merely measures the temperature of that part of the furnace or forging in its immediate vicinity, and, since many pyrometers are not positioned intelligently in relation to the shape and size of the forging and the known characteristics of the furnace, it is not surprising that results are unsatisfactory. Obviously, the remedy is to train men who are to take charge of important heat-treatment operations to be not only pyrometer readers, but also careful and accurate observers and to provide, if necessary, sufficient pyrometric instruments in reserve to enable temperatures to be taken in parts of the furnace, or on parts of the forging, which are not necessarily at the same temperature as the pyrometers used for recording.

Construction of Castle Donington Power Station

The civil engineering works for the new power station at Castle Donington, where six 100MW generating sets will be installed, are described. The work includes a foundation raft constructed of colloidal concrete, prestressed concrete foundation blocks for the generating plant, and welded structural steelwork with the boilers suspended from the roof beams.

THE Central Electricity Authority's programme of power station construction has, since the war, involved extensive civil engineering works at many different sites, and quite a considerable part of the annual output of the civil engineering industry is in the construction of power stations. Much of this work escapes relatively unnoticed in the technical press, for there is a great deal in common between the layout of one power station and another, and attention naturally tends to be given more to the plant installations when the completed station is described. Over the past few years we have described in these columns, as the occasions arose, various civil engineering achievements in thermal power station construction, but our articles generally referred to some special, more unusual aspect of the work. In this article, however, we have attempted to give a comprehensive account of the civil engineering works which must be completed when a new power station of substantial size is built.

Castle Donington power station, which is situated near Derby, beside the River Trent, is an ideal example for a description of this kind. It is a completely new station which is being substantially completed in one stage of construction, and it involves civil engineering works on a large scale with a total estimated cost of about £7,250,000. The way in which recent trends in plant installation have influenced the civil engineering can also be seen, for instance, in the design of the turbo-alternator foundation blocks. Six 100MW sets are to be installed, giving loads on the foundation blocks appreciably higher than those imposed by the 60MW sets previously standard, for the blocks are physically no larger. These foundation blocks, therefore, are of prestressed concrete.

Another recent trend has been to economise in constructional costs by reducing the size of the building in relation to the plant capacity. Thus, Castle Donington power station is more compact than many other C.E.A. stations. It also departs from the rather monumental style common in power station architecture, and aims at a much cheaper structure, designed in a functional manner. Economy of structure has not been limited, however, to the architectural treatment; the steelwork design, which makes extensive use of welded box sections, is noteworthy for its economy. The boilers have been suspended from the roof beams, and the separate boiler steelwork of older stations has been omitted.

Castle Donington is the largest single power station yet built in Great Britain, though other sites with "A," "B," and even "C," stations, have larger aggregates of power. It includes large substations for 132kV interconnection and for the 275kV "super-grid." The site layout is, therefore, particularly comprehensive and the station's design generally indicates trends which will be developed even further in newer stations. The High Marnham site nearby, where work has recently been started on a power station in which five 200MW sets will be installed, will illustrate a further stage of progress, incorporating many points of similarity with Castle Donington.

The first 100MW set will soon be in operation at the station, and the civil engineering works are largely completed, though appreciable work is still to be done in finishing the buildings, in site layout and so on. The 132kV substation is in operation and the 275kV section is well advanced.

The Site Layout

The accompanying plan, Fig. 1, shows the various installations at the power station site. The rather complex factors influencing the siting of a power station are generally well known. Briefly, the stations' position in relation to the load centres is important; also large quantities of various materials have to be handled, principally cooling water, coal, ash and boiler feed water. Frequently poor sub-soil is encountered on sites where these other requirements can be met, but at Castle Donington a reasonably good constructional site existed as well. Generally clay 2ft to 8ft in thickness overlies 10ft to 17ft of gravel, with marl and sandstone below the gravel.

The large areas taken up by coal sidings and tipplers and the coal store may be observed from the plan. An ash-handling plant is situated behind the electrostatic ash precipitators, and ash can be pumped, from a wet sump, through pipelines to gravel pits. The river intake and outfall are both fairly large works, and the cooling water pump house involved excavating a large foundation sump. The cooling towers are not of sufficient capacity for the entire station, but are needed to supplement the river-derived cooling water supply at times of low flow. The site is below the river level, and so the work included strengthening of the flood embankment and installation of surface water drainage, including pumping stations. These various sections of the work will now be described in greater detail, but an overall idea of the magnitude of the various aspects of the work is given by the table overleaf, in which are listed data relating to the operation of the station, and the principal quantities in the civil engineering works. The large quantities of fuel, cooling water, and so on, can be seen from the table.

Foundations of Main Building

The foundation loads imposed by the plant and structures at Castle Donington are somewhat heavier than has been customary in power station construction. The heaviest load from a single column is about 1400 tons, and the dead load which the turbo-alternator set imposes on the foundation block is 350 tons.

In the turbine house area the complexity of the sub-structure—involving large quantities of rather heavily reinforced concrete with 9ft 6in diameter cooling water ducts incorporated in it—combined with the need for speedy construction, led to an experimental use of colloidal concrete. A large strip of the foundations, 80ft wide, extending across the line between boiler and turbine houses and traversing the full length of 580ft of the building, carried the edge columns of both boiler and turbine areas (three rows of columns are carried here altogether) and thus needed to be of uniformly massive construction. This area was enclosed by steel sheet piling and excavated down to sound marl. A reinforced concrete raft 17ft 6in deep was then constructed in the cofferdam. Column footings occurring outside the area of the raft were spaced apart sufficiently to make piled construction more attractive, and the various clusters of piles were driven while construction of the raft was in progress. Bored piles were used; the stanchion base carrying the 1400-ton load needed thirty-six 19in diameter piles, each about 25ft long.

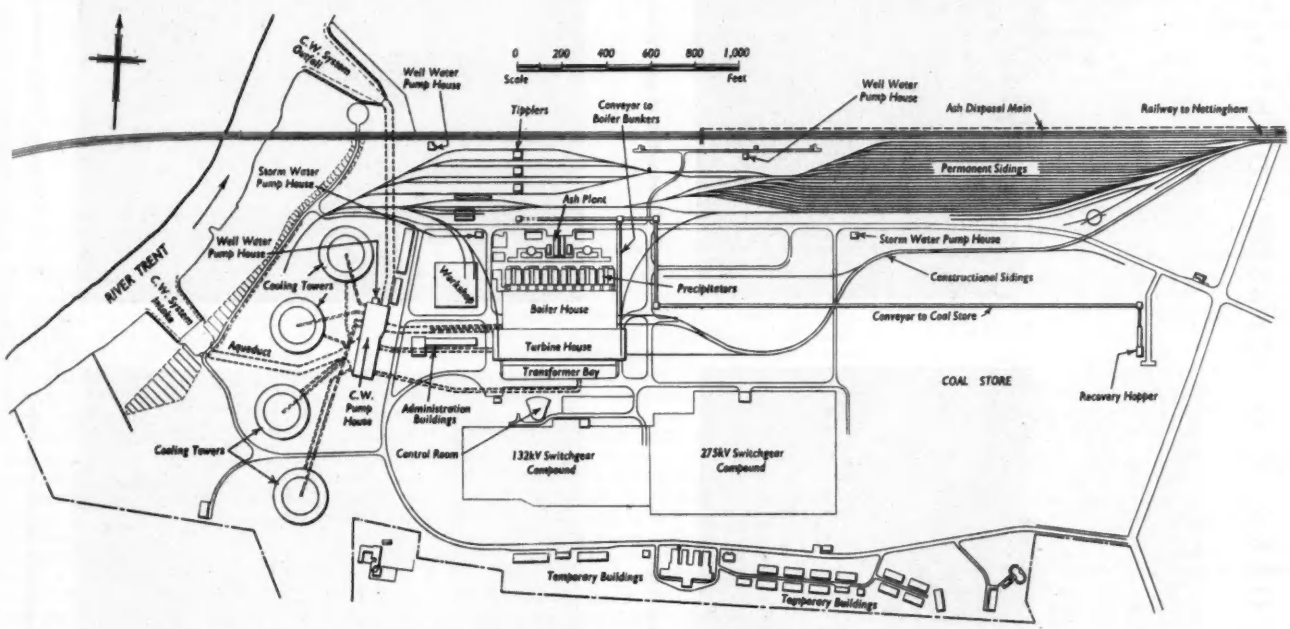


Fig. 1—Site layout at Castle Donington power station

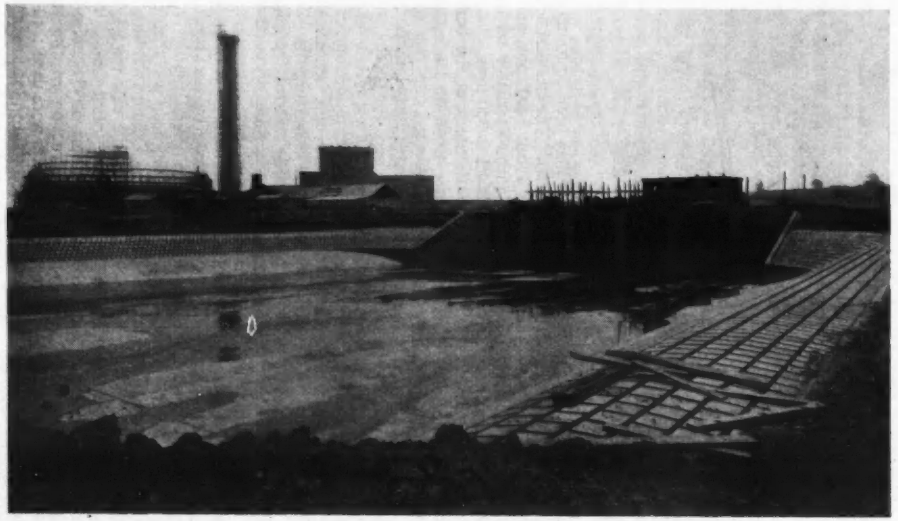


Fig. 2—Intake of cooling water system from the River Trent

Fig. 3—Construction of substructure of cooling water pump house, with twin intake culvert in foreground

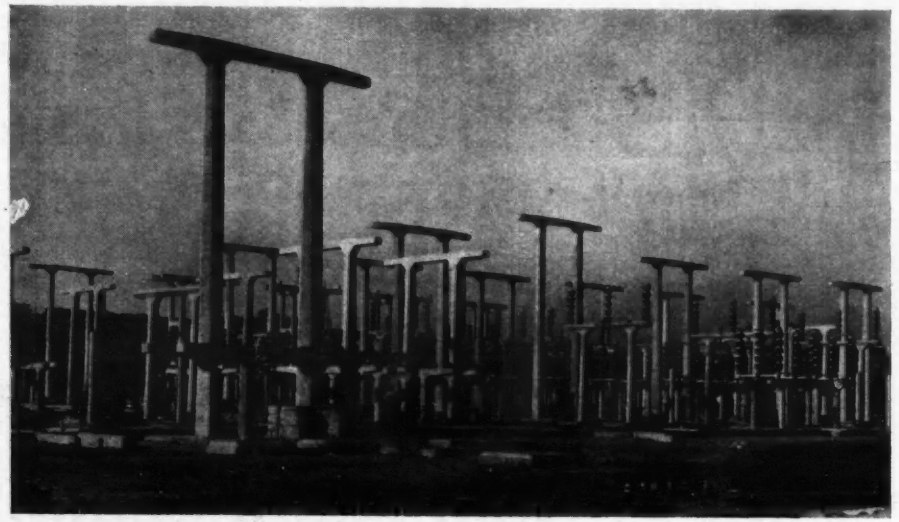


Fig. 4—Part of 132kV compound, with electrical gear being erected on the precast concrete structures

Fig. 5—Completed turbo-alternator foundation block, with installation of condenser plant in progress

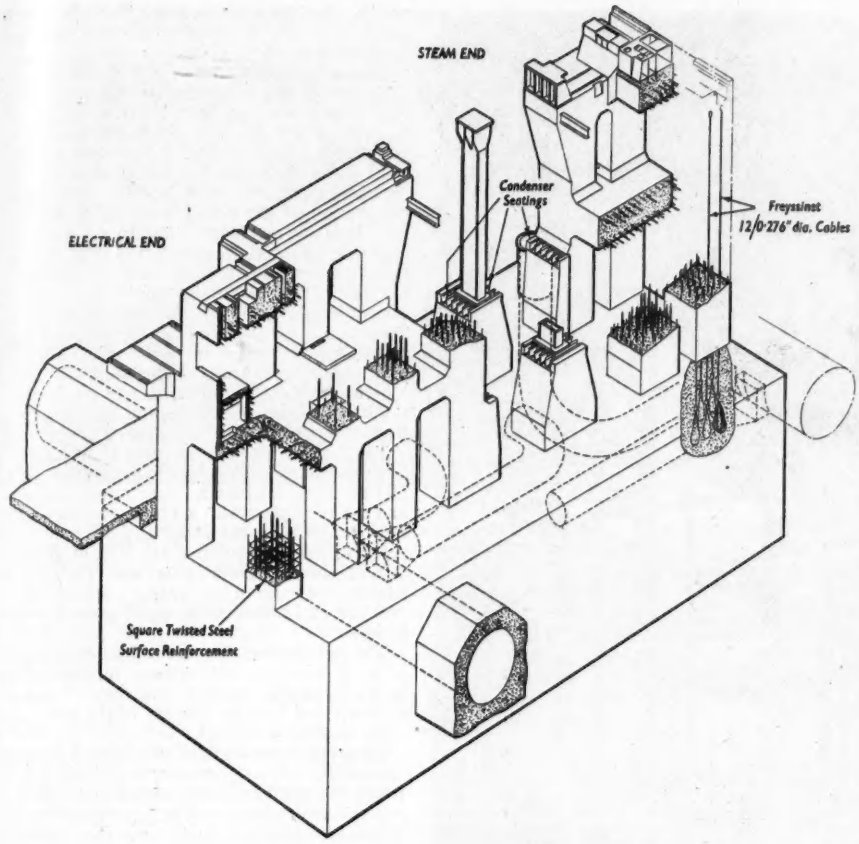


Fig. 6—Foundation block for 100MW turbo-alternator set

Colloidal concrete was used for the raft foundation in an attempt to reduce the number of joints and the rise in temperature of the " green " concrete. Coarse aggregate, 3in–1½in in size, was tipped directly into the concreting zone, and colloidal grout was pumped in afterwards from a battery of " Colcrete " mixers. The work was done in sections about 80ft square, and the colloidal grout needed to concrete each such area was placed, to the full depth, in one continuous operation lasting about twenty-four hours.

The foundation raft at Castle Donington is probably the largest application of colloidal concrete yet constructed in this country. We understand that its use for such heavy foundation work was considered to be satisfactory, provided that care was taken in keeping the stone and also other surfaces which were to be in contact with the colloidal grout, free from dust.

Six " wings " of the same depth as the main raft, and each 80ft long by 40ft in width, were built at intervals along the edge of the raft, as bases for the foundation blocks of the turbo-alternators. The same general method of construction with colloidal concrete was again used. All these works involved rather deep excavation ; appreciable inflows of water from the gravel were drained by pumping from sumps.

Turbo-Alternator Foundation Blocks

The overall size of each of the foundation blocks for the main generating sets is 80ft by 22ft by 30ft in height. Although referred to as a " block," each of these structures is complicated in shape, as the illustrations Figs. 5 and 6 show. There are in fact two " blocks," each pierced by large interior passages and spaces, one supporting the turbine and one the alternator. The space between is for the two condensers. This arrangement is heavily reinforced and calls for a high standard of workmanship ; in this case concrete with a twenty-eight days' strength of 4000 lb per square inch was specified.

In a foundation block of this kind, although the loads are compressive, the block has to sustain live loads as well, and so is designed to resist tensile stresses everywhere on its surface. For instance, in the event of unbalanced running of the set or of some rupture or fault while it was in operation, loading conditions on the block would be difficult to predict. This situation has generally been met in the past by reinforcing all the surfaces of the block with a mesh of steel. For the increased loads of the 100MW set, however, further precautions were considered necessary, and so the blocks are prestressed with twelve-wire cables, according to the Freyssinet system, to give a minimum compressive stress of 100 lb per square inch everywhere in the block when the working loads are imposed. The positioning of the cables was largely determined by the physical limitations of the space left in the block, and in fact a larger compressive stress could not have been obtained for that reason. There are 140 horizontal cables and 175 vertical ones, the latter being looped in the raft, under the block, so that they could be stressed from the top anchorage alone.

Structural Steelwork

The steel structure of the main building was designed according to B.S.S. 449. The largest column, carrying 1400 tons, is a 3ft by 5ft box, fabricated from steel plate up to 1½in thick. The welded box sections were shop fabricated, most of the site joints being riveted or bolted. However, the beams spanning the turbine house were brought to the site in halves, and a site-joint was made by welding. These beams span 108ft.

The suspended boiler steelwork is free to expand and contract as conditions require. Each boiler is carried principally on a main beam, positioned longitudinally in the " F " row at roof level and simply supported on knife-edge bearings. Subsidiary beams span transversely on each side of this main beam to continuous girders in the adjacent column rows, and there are suspension points for the boiler from the main beam and from the associated secondary beams. Each of these main boiler beams spans 56ft, imposes a load of about 1000 tons at each support, and has a depth of 12ft and weighs 32 tons.

Suspension of the boilers from the roof and

Principal Data for Castle Donington Generating Station

Main Power Station Plant

Turbo-generators :	
Capacity, MW	100
Number	6
Generating conditions	13·8kV, 50 c/s, 3000 r.p.m.
Generators 1–3	0·8 p.f.
Generators 4–6	0·9 p.f.
Boilers :	
Capacity, k lb/hr	830
Number	6
Steam conditions:	
Lb/sq in	1600
Deg. Fah.	1060
Transformers :	
13·8/132kV :	
Capacity, MVA	120
Number	3
13·8/275kV :	
Capacity, MVA	106
Number	3
132/275kV :	
Capacity, MVA	120
Number	2

Coal Handling and Stores

Normal coal requirement, tons per day	7100
Sidings : 24 exchange siding each for 60 wagons	
Wagon tipplers, number	4 (provision for 6)
Conveyors from wagon tipplers, number	2 (each of 480 tons per hour)
Conveyors to coal store:	one stocking out, two return
Capacity of each	480 tons per hour
Length, ft	1847
Distribution to coal store : one travelling wing tripper running on 31ft gauge, 112 lb rails.	
Reclamation from store : one r.c. recovery hopper with belt conveyors beneath. Coal is bulldozed into the recovery hopper. Coal recovery transporter on 31ft gauge track.	
Area of coal store, acres	40
Approximate storage capacity, tons	600,000

Cooling Water

Total requirement with 6 sets in operation :	
M.g. per hour	25
Cusecs	1100
Flow of River Trent :	
Range of flows, cusecs	350 to 20,000
Average summer flow, cusecs	1000
Average winter flow, cusecs	2000 to 3000
Cooling towers :	
Number	4
Capacity of each, m.g. per hour	4·5
Height, ft	300
Diameter at base, ft	210

Main Pumping Station

Size of building, ft	290×41
Depth of sump, ft	40
River water pumps :	
Number	6
Capacity of each g.p.m.	70,000
Design head, ft	38
Power of driving motor, h.p.	1030
Tower pumps :	
Number	4
Capacity of each, g.p.m.	75,000
Design head, ft	59·5
Driving motor, h.p.	1710
All pumps are horizontal-spindle, centrifugal machines.	
Diameter of principal c.w. conduits, ft	9·5
Diameter of branch pipes to condensers, ft	4

Cooling Water Intake Works

Size of intake channel in river, ft	150×106
Coarse screens :	
Number	6
Size, ft	15·5×9
Construction	4in×¾in M.S. flats at 3¾in centres
Band screens :	
Number	6
Width, ft	8
Penstocks :	
Number	12
Size, ft	6×8
Note.—Each band screen can be isolated by a pair of penstocks.	
Aqueduct from intake to pump house :	
Length, ft	600
Cross section, ft	Twin culverts, each 13·5×6·5

Ash Handling and Disposal

Total quantity produced, tons per day	1000
Size of ash sump, ft	49×30×33 deep
Coarse ash removed	Six 10-ton lorries
Ash pumping mains:	
Number of mains	4
Bore of mains, in	14
Material and thickness of mains	1in spun cast iron
Initial length of mains, ft	9200
Ultimate length of mains, ft	13,000

Civil Engineering Works

Site drainage:	
Area of site, acres	114
Area of buildings, acres	9
Pumping stations, Number	2
Storm water pumps in each station, Number	2
Capacity of each, g.p.m.	4000
D.W.F. pumps in each station, Number	1
Capacity of each, g.p.m.	750
Site Water Supply :	
Total requirement, g.p.d.	350,000
Pumping stations, number	3
Ultimate pumping capacity, g.p.h.	36,000
(Three 3000/4000 g.p.h. vertical-spindle pumps in each station)	
Initial installation, g.p.h.	23,000
Service reservoirs capacity, m.g.	1
Drinking water reservoirs (local authority's supply) : capacity, m.g.	0·012

Civil Engineering Quantities

Excavation, cu. yds	315,000
Concrete, cu. yds	120,000
Structural Steelwork, tons	9200
Reinforcing steel, tons	2100
Number of piles in main foundation (19in dia. and about 25ft long), Number	900
Colloidal concrete in main foundation :	
Main raft, cu. yds	24,000
Six turbine bases, cu. yds	17,000
Quantities in each of the two chimney bases:	
Piles 19in. dia., number	209
Octagonal base, depth, ft	8
Distance across flats, ft	68
Height of chimney, ft	425
Minimum internal diameter, ft	23
Weight of chimney, tons	5300
Weight of base (excluding piles) tons	2600

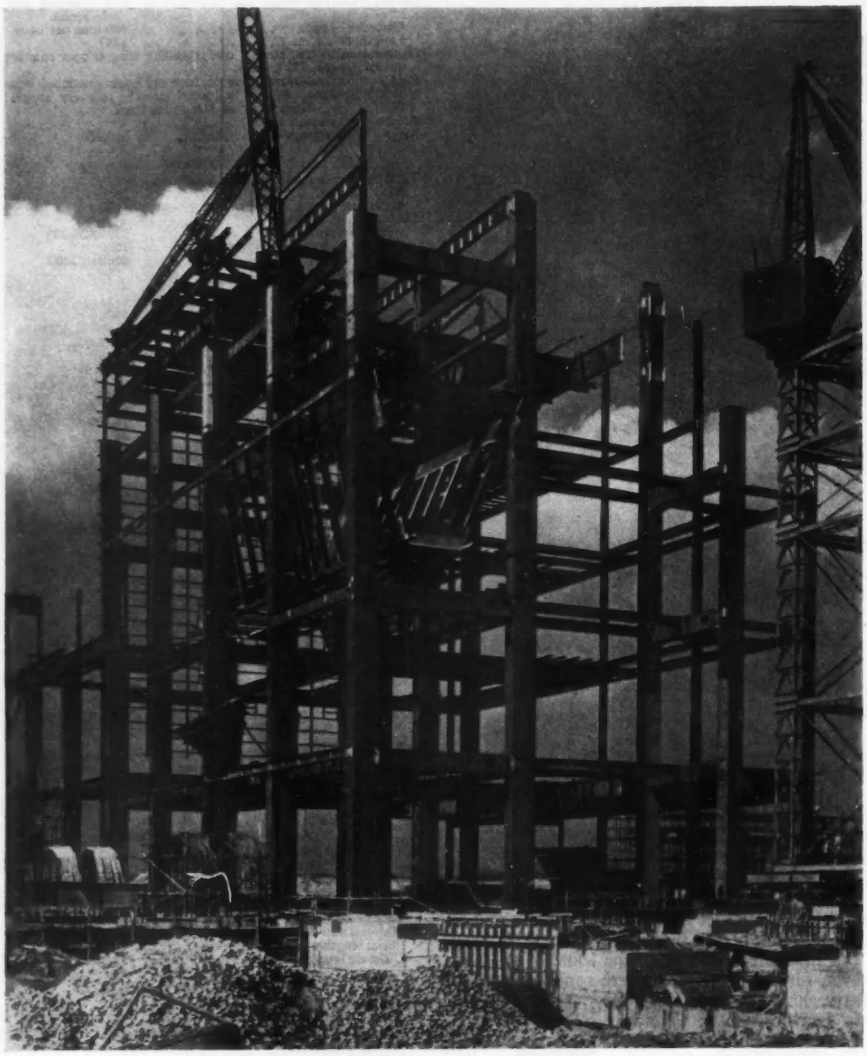


Fig. 7—An early stage in the construction of the boiler house steelwork. The bunkers are between column lines D and E. Note the knife-edge support to carry the longitudinal boiler beam on the F column, the transverse portal bracing between D and E lines, and the longitudinal portal bracing in F line

the intense concentration of plant within the building required the introduction of some unusual features in the steel framework. The boiler supporting beams are arranged to take the weight of the boiler through a number of screwed rods with rocker plates to allow for slight movement and adjustment in level, which will be brought into use as the boiler is being built. Differential deflection of the supporting points is important to the boiler manufacturers, and to reduce this the whole of the steelwork was designed in mild steel instead of high-tensile steel, which would give rise to larger deflections. The total deflection at the supporting points of the boiler is made up partly of the bending of the beams and partly by the shortening of the steel columns. The E line of columns is loaded not only by the boiler but by the bunkers and slight movements at roof level must therefore occur in these columns as the bunkers are filled or emptied.

The building is 150ft high and therefore subject to considerable wind forces, and special consideration was given to its lateral stability. In many buildings this stability is provided by the brick or concrete walls, but in this case the asbestos cement sheeting used for the cladding of the whole of the structure above the turbine level can have no stiffening effect. Diagonal lattice bracing is not practicable within the structure, since it would interfere with plant or access. Lateral rigidity for the whole framework is therefore provided by a series of portal frames and horizontal bracing in the horizontal planes of the floors. Longitudinal stability of the boiler-house is provided by a series of portal girders between the F line columns (which are between the boilers) and in the lateral direction by a rigid frame construction between the D and E line columns.

The heavier columns on the B, C, D, E, and F lines are of welded plate construction, which provides the maximum economy of material, neat appearance and rigidity. These columns are designed with fixed ends at the base, the end of the column being machined to bear on a steel slab with substantial holding-down bolts to take any overturning moment. The G and H lines of columns, which are similar in section to the others, are designed as pairs of joists welded together by their toes to form a welded box. All the main columns and the heavier plate girders, crane girders in the turbine house and parts of the bunkers are of welded construction, but the site connections are generally bolted or riveted, as already noted. The total weight of steelwork is 9200 tons. Erection of the boiler-house steelwork was carried out from a derrick mounted on an 80ft gabard, and a second derrick mounted on the roof steelwork. The two derricks are shown in Fig. 7, and the general appearance of the boiler and turbine house steelwork is clearly shown in Figs. 7 and 8.

Architecture of Main Building

The architects gave a good deal of thought to the group planning of the various masses involved at Castle Donington. For example, the four large cooling towers which are twice the height of the main station, have been disposed in a curve, reflected by the bend in the river to the west, thus providing a background for the various ancillary buildings in this area. The office block and canteen are pleasantly disposed in an open court formed by the station, workshops and cooling water pump house.

The main station is clad in concrete up to 35ft level (operating floor level) using precast concrete facing slabs finished externally with exposed granite aggregate. Above this level the walls are clad in asbestos cement sheeting, and for this contract a new "panel sheet" was designed. All the cladding with this sheeting was done by two men. The roof consists of lightweight steel decking with skylights. Additional thermal and acoustic insulation is given to the turbine house by perforated asbestos cement insulation board fixed in aluminium tees. There are large roof lights in the turbine house with additional strips of patent glazing at cill level round three walls. Large steel ventilating louvres are fitted on the north and south elevations; they are motorised and remotely controlled from small cubicles on the operating floor.

The station entrance is incorporated into a large glazed screen 40ft high in squares of patent glazing using, alternately, clear rough-cast glass and a similar glass with a white paint film fused into the glass on the inner surface. The conveyor towers and gantries are clad in asbestos cement sheeting conforming with the general scheme, and most of the smaller ancillary buildings are of brickwork in light golden brown facings.

The turbine room interior is finished in shades of light blue-grey with crimson turbine casings on light oatmeal coloured floor tiles. There are exposed steel bunkers painted bright green and aluminium hand railings.

Although the power station is not yet finished, a good idea of its appearance is given by Fig. 9. It will be clear from the foregoing that a marked attempt at economy and at a more functional appearance has been made, when the station is compared with many other recent C.E.A. power stations. This trend is also apparent in some other recent designs—Marchwood, for instance where aluminium cladding is used. The cubic content of the main building at Castle Donington is about 28 cubic feet per kilowatt of installed capacity, a figure which compares with about 42 cubic feet per kilowatt, a normal figure for a 60MW station. The reduction is, of course, due both to the compactness of the 100MW sets and the general layout. An approximate comparison by quoting weight of structural steel per megawatt is also sometimes made. For instance, the semi-outdoor power station at Ince (THE ENGINEER, December 18, 1953) needed 18·02 tons of steel per megawatt of installed capacity (and, incidentally, enclosed 24·4 cubic feet per kilowatt), the corresponding figures for Castle Donington being 15·3. Steel-work of the Ince station was probably reduced by about 10 per cent due to the semi-outdoor design.

Cooling Water Installations

Figures for cooling water requirements, river flows and capacities of the cooling towers are shown in the table. The function of the cooling towers in supplementing the river-derived cooling water at times of low river flow is clear from these figures. An idea of the magnitude of the pump house is also given, the pumping plant being listed. The pumps are installed in a sump 40ft deep, of massive reinforced concrete construction; the intake culvert and pump house substructure are shown in Fig. 3.

The river intake is an elaborate structure, illustrated on page 558 in Fig. 2, with coarse screens, mechanically raked fine screens and penstocks; behind these installations, a transition channel joins with a dual culvert with two 13ft 6in by 6ft 6in channels, leading to the pump house about 600ft away. The river outlet is built in a similar manner, but has only stoplog grooves for water control. Wide channels have been constructed at both the intake and outlet to give low velocities of flow in the river, and the embankments are revetted with precast concrete blocks, grouted with bitumen.

From the pump house, water is circulated to and from the condensers of the main sets, and, as required, to the cooling towers, through 9ft 6in diameter pipes, with branches 4ft in diameter to each condenser.

The four cooling towers are each 300ft in

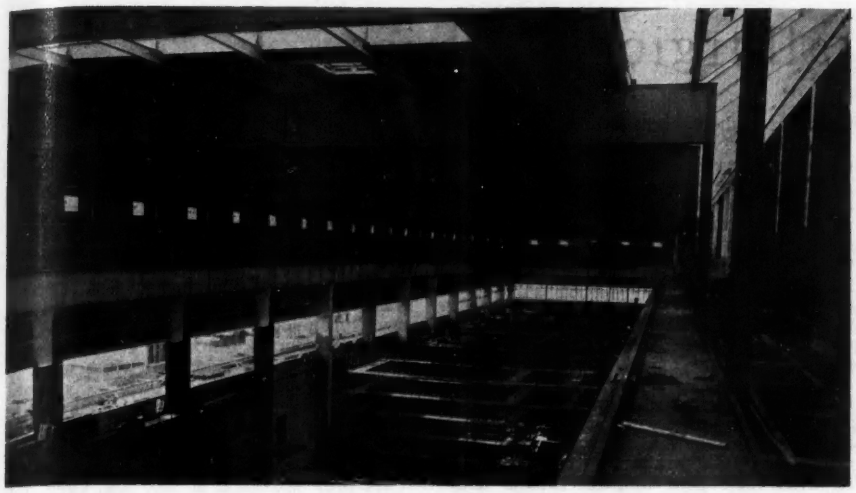


Fig. 8—Turbine house steelwork. The clean lines of the steel structure are evident in this illustration, taken from crane beam level before construction of the interior finishing and decorations. The first turbo-block, in the background, is completed and installation of machinery is proceeding

height, with a pond diameter of 210ft. Although of large size, their construction follows the general lines now well established for such structures.

Coal and Ash Plants

Referring back to the plan of the site, it will be seen that considerable areas are taken up by the coal sidings and coal store. Coal is brought along the adjacent branch line, which is now used exclusively for coal traffic from nearby collieries.

The sidings layout envisages handling up to eleven coal trains, each of up to sixty trucks, daily, with twenty-four exchange sidings, twelve each for full and empty trains. Only half of this number is being laid initially. There are initially two twin wagon tippler installations, involving some heavy reinforced concrete work, from which coal is taken by conveyor belt either to the hoppers above the boilers, or to the coal store. The store has stocking and recovery conveyors running along a central track about 1850ft long. A travelling wing tripper for spreading the coal straddles the belts, and there is a recovery pit and conveyors at the end of the store. Coal will be bulldozed into this pit when the entire requirements of the station are met from the store, but normally coal will be recovered by the grabs of a recovery transporter which travels on the 31ft rail track. This machine can reach out a distance of 55ft and load about 480 tons of coal an hour on to the conveyor.

Ash from the boilers and dust from the electrostatic precipitators (there are two precipitators corresponding to each boiler) is sluiced to a large sump. Here a grab picks up the coarse ash and loads it into lorries. The fine ash is pumped, as slurry, through 14¼in diameter cast iron pipes to gravel pits about 2 miles away. The pipes have a wall thickness ¼in greater than standard cast iron pipes, because of the abrasive nature of the slurry. With this precaution they are expected to last the full period of 25 years, which is estimated will be needed to fill the pits completely.

Other Civil Engineering Works

Some of the other civil engineering works at the Castle Donington site have already been briefly mentioned. They include the construction of roads, and of rail access to various buildings, in addition to coal sidings. Surface water drainage of the site was also an important task. The drainage system leads partly to a gravity outfall in the flood embankment, controlled by a flap valve. There are also two pumping stations which serve the remainder of the site, and which handle all drainage when the river level is high. They each contain two storm water pumps of 4000 g.p.m. capacity and a dry weather flow pump of 750 g.p.m. capacity. A small purification plant serves the main buildings, site offices and camp.

It may be recalled that the deep excavations for the main works passed through gravel containing appreciable quantities of water. Various supply pipes were installed in the trial pits for these excavations, and they have been linked to three pump houses, such that a supply of 350,000 g.p.d. has been obtained, sufficient for make-up water for the boilers, and for other purposes on the site. A service reservoir of 1 m.g. capacity has been built in the hillside nearby, to complete this water supply system.

Other buildings on the site include the workshop and stores building, canteen, offices, garage, locomotive shed and a control room building. The latter serves the main power station; as a result of the spatial economy in the layout of the main building, the control room has been built separately, instead of in the more usual position overlooking the turbine hall. The workshop and stores building has a roof of aluminium "sandwich" construction.

The considerable assemblage of pylons, &c., in the two switch yards (Fig. 4) are all built of reinforced concrete. Many of them were cast on the site, where manufacture of concrete was carried out at a batching and mixing station equipped with weigh-batching plant and a 1 cubic yard mixer. A small casting bed was also used here and many of the precast prestressed roof beams of the ancillary buildings, as well as the switchyard structures were cast on it.

One major work remains to be mentioned, namely, the chimneys. There will eventually be two chimneys; one has been built, and the second is well advanced. They are each to be of reinforced concrete construction, 425ft in height, and with a minimum internal diameter of 23ft. Each one is carried on a substantial "cap" of cast-in-situ piles, construction of which formed part of the main foundation contract.

Castle Donington power station is being constructed by the Central Electricity Authority, design of all mechanical and electrical matters being in the hands of the Authority's East Midlands Division. The civil engineering works described in this article are the responsibility of the consulting engineers, Messrs. Freeman, Fox and Partners. The architects are Messrs. Clifford Tee and Gale. The main civil engineering contractor for the work is Taylor Woodrow Construction, Ltd. The following firms also carried out substantial sections of the civil engineering works: preliminary works, William Moss and Sons, Ltd.; structural steelwork, Sir William Arrol and Co., Ltd.; colloidal concrete work and cast-in-situ piling, The Cementation Company, Ltd.; chimney superstructures, J. L. Keir and Co., Ltd.; cooling tower superstructures, Mitchell Construction, Ltd.; electrostatic precipitator structures, Bierrum and Partners, Ltd.

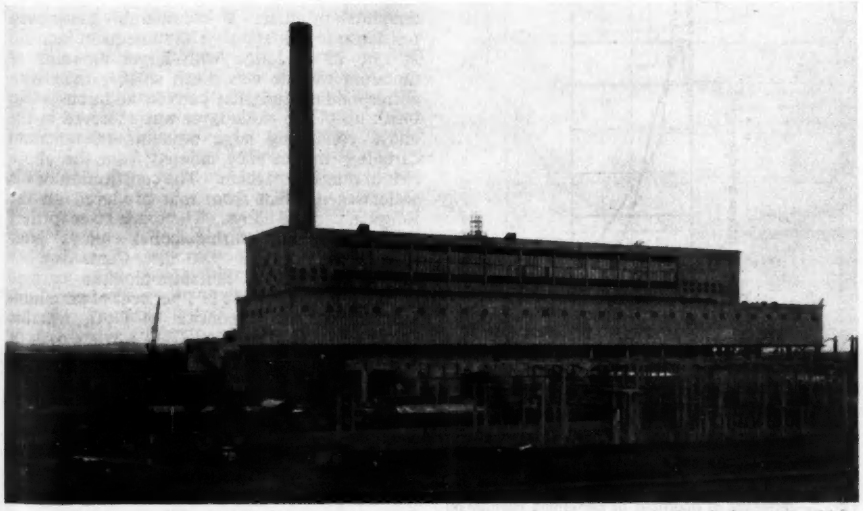


Fig. 9—Castle Donington power station. The main building is shown nearly complete, scaffolding for the second chimney just being visible above the roof

Technical Reports

The Strength Properties of Timber. The 2cm Standard for Tests of Small Clear Specimens. Forest Products Research Bulletin No. 34. H.M. Stationery Office. Price 2s. 6d.—The original standard for testing timber introduced over fifty years ago and adopted by all the English-speaking timber testing countries is based on the use of test pieces of 2in square cross-section. Many Continental countries, however, use a testing system which employs test pieces of 2cm cross-section. The Forest Products Research Laboratory has recently adopted the smaller cross-section for testing samples from trees of small dimensions from British plantations. The bulletin describes the methods of test adopted in using the 2cm standard and compares the results of tests with those obtained when using the 2in scheme. Data from tests on twenty-nine hardwoods and twelve softwoods are given and diagrams are included which provide a comparison of the results obtained with different species.

Post War Building Study No. 33: *Basic Design Temperatures for Space Heating.* H. M. Stationery Office, price 3s. 6d.—This report has been prepared by a study committee, appointed by the Councils of the Institutions of Mechanical Engineers, Electrical Engineers, Gas Engineers, and Heating and Ventilating Engineers. It was considered desirable to establish the minimum design temperature on a more accurate basis. Information is given on the external air temperature and its duration which should be assumed in the design of space heating installations in the United Kingdom, intended for continuous operation. The report deals also with installations which are intended to be run at less than their full rate for at least part of their weekly cycle of operations.

Metallurgical Topics

Oxidation of Carbide Alloys for High-Temperature Service

In the course of the development of sintered high melting point carbides as materials for high-temperature applications, interest has extended from the original bonded titanium carbide to multicarbide alloys which contain, besides titanium carbide, the carbides of tungsten, chromium or tantalum. Many of these have been shown to possess good creep and fatigue properties at high temperatures. A further requirement is resistance to scaling. Work has been carried out by J. Hinnüber, O. Rüdiger and W. Kinna* with the object of studying the influence on the oxidation process of various additions to bonded titanium carbide, and so assisting in the systematic development of these hard metal alloys for use at high temperatures. The work was based on 80 : 20 titanium carbide-cobalt, part of the titanium carbide being replaced by tungsten carbide (1 to 60), or chromium carbide (1 to 20), or tantalum-niobium carbide (1 to 40). In order to ascertain the influence of the added carbide on the oxidation of titanium carbide alone, several cobalt-free multicarbide alloys were also included. Earlier work by W. Kinna and O. Rüdiger† showed that between 600 deg. and 1000 deg. Cent. two oxide layers were formed on the titanium carbide-cobalt alloys, with about 20 per cent of cobalt. The outer layer consisted of Co_3O_4 or CoO, depending on the temperature, and the inner layer of rutile, TiO_2, with embedded particles of metallic cobalt. These observations can be explained on the assumption that the adjacent structural consituents oxidise differently and independently of one another. According to the temperature and oxygen pressure the rutile layer from the titanium carbide crystals grows more quickly or slowly than the cobalt oxide layer derived from the cobalt matrix. At normal pressure and a temperature of 600 deg. Cent. the cobalt oxidises quicker so that cobalt oxide covers the oxidised titanium carbide phase. At a pressure of 5.10^{-3} atmosphere, on the other hand, the rutile layer grows over the cobalt oxide. At 1100 deg. Cent., as a result of a reaction between the two oxide layers, the compounds $CoTiO_3$ and Co_2TiO_4 are formed. When another carbide is also present a reaction between the oxidation products, which may strongly influence the further oxidation process, may occur at temperatures below 1000 deg. Cent.

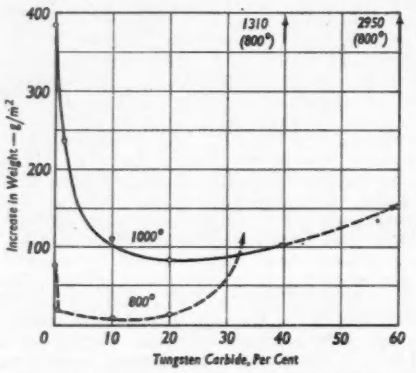


Fig. 1—Influence of additions of tungsten carbide on the rate of oxidation of titanium-carbide-cobalt alloys with 20 per cent of cobalt, heated for twenty-five hours at 800 deg. or 1000 deg. Cent.

Influence of Tungsten Carbide

The influence of additions of tungsten carbide on the oxidation of titanium carbide-cobalt alloys is shown in Fig. 1. Specimens containing small percentages of tungsten carbide, heated at 800 deg. and at 1000 deg. Cent. in air for twenty-five hours, scaled considerably more slowly than specimens without tungsten carbide additions. In specimens with a high tungsten carbide content, however, the rate of scaling increased. The fact that small additions of tungsten carbide act strongly in hindering oxidation was at first surprising, because it is known that in tungsten carbide-cobalt alloys the tungsten carbide and the tungstic oxide derived from it are by no means favourable to oxidation resistance. The scaling of titanium carbide-tungsten carbide-cobalt alloys with tungsten carbide up to 20 per cent was shown to be parabolic with respect to time, indicating that the oxide layer formed protects the specimen from further scaling. For alloys with higher tungsten carbide content, e.g. more than 40 per cent, this is no longer so. The scaling of alloys of this type at 800 deg. Cent. follows a linear course. At a temperature of 1000 deg. Cent., however, these high tungsten carbide alloys behave more favourably than at 800 deg. Cent. and scaling obeyed an essentially parabolic relation. This applies to the alloys investigated, bonded with 20 per cent of cobalt. If the cobalt bond is only 6 per cent, scaling again follows a linear law in relation to time. The cobalt content is thus of great influence on the rate of oxidation, since, through the formation of a protective complex oxide layer, oxidation is hindered. The influence of the tungsten carbide is explained on the assumption (supported by metallographic evidence) that the WO_3 formed by oxidation is dissolved in the TiO_2 diminishing the rate of diffusion of oxygen in the rutile lattice, and so causing the rate of oxidation to fall sharply. With higher tungsten the amount of tungstic oxide formed exceeds its solubility limit in rutile ; and, besides the oxides CoO and TiO_2, the compounds $CoTiO_3$, Co_2TiO_4 and $CoWO_4$ appear in the scale. Thus the phase boundaries increase in number and present a further obstacle to diffusion with the result that there is an additional reduction in the rate of oxidation. When the percentage of tungsten carbide is so high that free tungstic oxide is formed in the scale the rate of oxidation rises rapidly and is still further increased by the tendency of the scale to crack and break off.

Influence of Chromium Carbide

Small additions of chromium carbide, Cr_3C_2, result in an increase in the rate of oxidation at 1000 deg. Cent. Only with greater amounts of chromium carbide (e.g. 5 per cent or more) is a definite decrease in the rate of oxidation to be observed (Fig. 2). This reduction in the rate of oxidation occurs when the solubility limit of chromium oxide in rutile is exceeded, and is due to the formation of cobalt titanate ($CoTiO_3$) and chromium oxide (Cr_2O_3). The cobalt-free titanium carbide-chromium carbide alloy with small amounts of chromium carbide also shows a high rate of oxidation at 1000 deg. Cent. Reference is made to a peculiarity in the oxidation of "hard metals" containing chromium carbide which may explain some contradictory conclusions in published reports. Chromium carbide powder is liable to surface oxidation, which tends to prevent compact sintering. Such porous hard metals containing chromium carbide may fall to powder after prolonged heating at 500 deg. or 600 deg. Cent., whereas they become covered with a good protective layer at 1000 deg. Cent. A specimen pretreated at 1000 deg. Cent. was subsequently resistant at 600 deg. Cent. if the protective layer had suffered no mechanical damage. Apparently the layer formed at 1000 deg. Cent. was able to grow over the pores or defective places and thus hinder the progress of scaling. This behaviour on prolonged heating at 500 deg. or 600 deg. Cent. was not observed in specimens with a porosity below about 1 per cent.

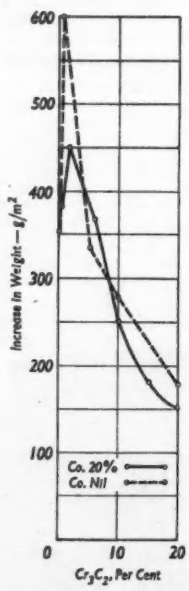


Fig. 2—Influence of additions of chromium carbide on the rate of oxidation of 80 : 20 titanium-carbide-cobalt alloy, and of cobalt-free titanium carbide, heated for twenty-five hours at 1000 deg. Cent.

Influence of Tantalum Carbide

The effect of additions of tantalum-niobium carbide on the scaling of titanium carbide-cobalt alloys, heated for twenty-five hours at 800 deg. and at 1000 deg. Cent., is shown in Fig. 3. Like tungsten carbide, tantalum carbide in small amounts produces a considerably improved resistance to oxidation. The subsequent increase in rate of oxidation with larger amounts of tantalum carbide was much smaller than with corresponding tungsten carbide additions. No break up of the oxide layer was observed in the alloys containing large amounts of tantalum carbide ; in this they differed from the alloys rich in tungsten carbide. The constitution of the scale was different from that produced on the tungsten carbide alloys. The oxide layer formed on the titanium carbide-cobalt alloys after seventy-five hours at 1000 deg. Cent. depends on the amount of tantalum-niobium carbide added. In the presence of 1 per cent of tantalum-niobium carbide it consists of CoO, metallic cobalt and a solid solution $(Ti, Ta, Nb, Co)O_2$ of the rutile type ; with 5 and 10 per cent of (Ta, Nb)C, of CoO and $(Ti, Ta, Nb, Co)O_2$; and with still greater amounts of (Ta, Nb) C, entirely of $(Ti, Ta, Nb, Co)O_2$. These conclusions apply to alloys containing 20 per cent of cobalt and less than 40 per cent of tantalum-niobium carbide. When the cobalt content was only 4 per cent a marked deterioration in resistance to oxidation set in with the formation of Ta_2O_5 and Nb_2O_5 if the tantalum-niobium carbide content exceeded 20 per cent. This example, and that already

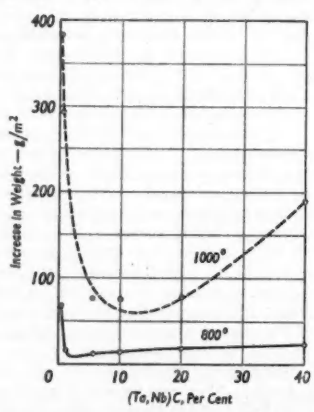


Fig. 3—Influence of additions of tantalum-niobium carbide on the rate of oxidation of titanium-carbide-cobalt alloys with 20 per cent of cobalt, heated for twenty-five hours at 800 deg. or 1000 deg. Cent.

* *Archiv für das Eisenhüttenwesen*, April, 1956, page 259.
† *ibid*, 1953, vol. 24, page 535.

mentioned in connection with tungsten carbide additions, illustrates the great influence that cobalt content may have on the oxidation process and the important effect of the cobalt bond in determining resistance to scaling.

Free-Cutting Steels

DURING the past twenty-five years investigations have led to important improvements in the machinability of steels for use in automatic machines. Factors contributing to this improvement (composition, heat-treatment, and cold working) have been summarised on the basis of published information by H. Müller.[1] At one time softness was regarded as a prime essential for easy machining and a carbon content of 0·06 to 0·08 per cent was advocated. Later, the detrimental effect of high ductility was recognised. The requirement for good machinability, according to Dr. C. Sykes,[2] is the somewhat incompatible "combination of low hardness and low ductility." Thus, as a compromise, higher carbon is generally employed. Recent work has shown that steels with a carbon content of about 0·2 per cent can be machined best. This is illustrated by the investigations of A. Schepers,[3] who employed a short-time test in which the

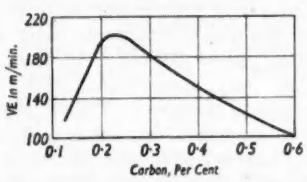


Fig. 1—Influence of carbon content in the test with steadily increasing cutting speeds up to the value (*VE*) reached on breakdown of the tool (Schepers)

cutting speed was steadily increased until it reached a value at which breakdown of the tool occurred. This greatest value in metres per minute, attained by the cutting speed, was taken as a measure of the machinability of the steel and was designated the *VE* value. Fig. 1 shows the effect on machinability of carbon content in steels containing 0·35 to 0·58 per cent of manganese and 0·17 to 0·31 per cent of silicon in the lower carbon range, and 0·52 to 0·80 per cent of manganese and 0·24 to 0·28 per cent of silicon in the higher carbon range. It indicates that optimum machinability of steels which differ essentially only in carbon content is obtained with 0·22 per cent of carbon. In a series of steels differing from those of Fig. 1 only by the presence of 0·16 to 0·21 per cent of sulphur the best machining properties were obtained when the carbon content was again a little over 0·2 per cent. In a similar set of high-sulphur steels with low silicon (0·03 to 0·08 per cent) easiest machining was obtained at 0·18 per cent carbon. The sulphur content of free-cutting steels is usually between 0·15 and 0·30 per cent. A high sulphur content must be accompanied by increased manganese to form manganese sulphide and ensure against red-shortness. Free-cutting steels, according to authorities quoted by Müller, can be rolled better if the sulphur is added to the steel as manganese sulphide, sodium sulphide or sodium bisulphite. Segregation can be reduced by keeping the ingot size below 2·5 tons.

Increase in either silicon or manganese content impairs machinability. The manganese not combined with sulphur as manganese sulphide should be 0·3 to 0·45 per cent. Aluminium additions are also undesirable on account of the formation of alumina inclusions. Unkilled steels are machined more easily than killed steels because of the smaller number of oxide inclusions in the unkilled steels.

A high phosphorus content promotes ease of machining, but on account of its very pronounced embrittling influence this action of phosphorus cannot be utilised with safety. For the upper safe limit of phosphorus in free-cutting steels Müller gives 0·10 per cent in basic open-hearth steels and 0·12 per cent in basic Bessemer, figures which are considerably higher than are generally considered desirable, especially in view of the tendency of phosphorus to segregate. The addition of 0·1 per cent or more of lead is an effective aid to machinability. This was well illustrated in Schepers' short-time tests, which yielded the following typical results for cutting speeds at breakdown of the tool :—

Carbon, per cent, (approx.)	Lead, per cent	*VE*, metres/min.
0·1	Nil	140
0·1	0·31	215
0·35	Nil	160
0·35	0·21	200
0·55	Nil	130
0·55	0·22	165

Though sulphur may have a more pronounced effect than lead in promoting ease of machining, the advantages of lead are very great in that the mechanical properties of lead-bearing steels are much superior to those of steels high in sulphur, the transverse ductility of which is very low.

Müller also refers to the favourable effect of cold working of mild steels to a hardness of about 200 Brinell, and to the fact that in steels containing 0·1 per cent of carbon quenching from above 900 deg. Cent. improves their machinability. For steels of higher carbon content a spheroidising treatment by which the steel is brought to a Brinell hardness of about 200 is recommended to give good machinability. Müller's paper ends with a brief description of the various methods of testing machinability, and is a useful summary of published work with over seventy references to the literature of the subject. In this connection, however, it may be mentioned that one of the best discussions of the characteristics of free-cutting steels is that contained in the chapter on "Bright and Free-Cutting Steels" in R. T. Rolfe's *Steels for the User*.[4] This account is of special interest because it is based on the personal experiences of the author and contains reports of commercial investigations, the results of which have an important bearing on the selection of free-cutting steels for various purposes.

REFERENCES

[1] *Stahl und Eisen*, September 8, 1955, Vol. 75, page 1171.
[2] Institution of Mechanical Engineers, Conference on Machinability, May, 1946, page 1.
[3] *Stahl und Eisen*, September 8, 1955, Vol. 75, page 1176.
[4] Third edition, 1956, pages 77 to 112. Chapman and Hall, Ltd.

Heat-Treatment of Manganese Steel

THE hardness and internal stress produced in heat-treating unstable austenitic manganese steel have been studied by H. Bühler and E. Herrmann.* The influence of time and temperature of

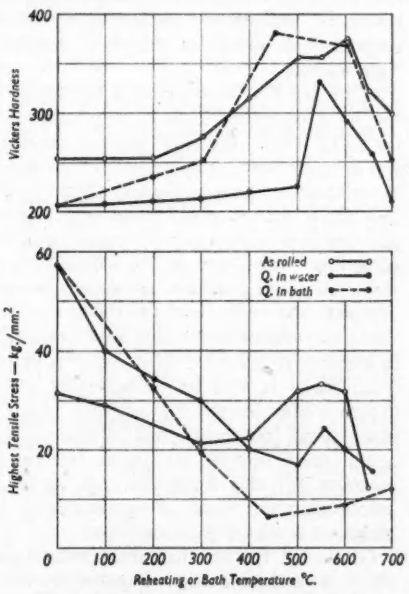


Fig. 1—Effects of reheating manganese steel

reheating of the rolled material and of the steel after quenching in water from 1050 deg. Cent. was investigated in steel containing carbon 1·2, manganese 13·6 per cent. Internal stresses were determined by the method of Heyn and Bauer on specimens about 15mm in diameter. The effect of quenching into oil, salt or lead baths at different temperatures, followed by cooling in air, was also investigated. Fig. 1 shows the hardness obtained and the highest tensile stress present in relation to the reheating temperature, held sixty-seven minutes, after quenching in water from 1050 deg. Cent., and to similar reheating of the steel in the as-rolled condition. It also shows the effect of heating the steel at 1050 deg. Cent., transferring it to a hot bath for five hours and then cooling in air.

It is claimed that these data will serve as a guide to the choice of heat-treatment designed to give a required hardness with the lowest possible residual stress, and it is concluded that the most favourable treatment is likely, in most cases, to be a hot-bath hardening.

It is unfortunate that no measurements were made of ductility after the treatments employed. The ductility of water-quenched manganese steel after reheating at temperatures between 400 deg. and 650 deg. Cent. is well known to be extremely low, and no data are given for ductility after hot-bath hardening. In general, no advantage accrues from the use of manganese steel hardened throughout. Abrasive pressure and impact in use are generally sufficient to produce a work-hardened surface on the steel in the water-quenched condition with excellent resistance to wear. If high hardness is required in the initial stages of service, before the full wear-resistance is developed, this is probably best achieved by coating the surface with a weld deposit containing very hard particles of a material such as tungsten carbide. When high hardness is required throughout the component, without excessive brittleness, it is usually preferable to employ a hardened and tempered high carbon steel of lower alloy content, such as a 3 per cent chromium-0·5 per cent molybdenum steel with 0·5 to 1·0 per cent of carbon, according to the hardness required.

* *Archiv für das Eisenhüttenwesen*, April, 1956, page 269.

Nitrocycle Case Hardening

A MODIFIED method of nitriding steels, known as the "Nitrocycle" process, has been developed by the Oil Well Supply Division of United States Steel Corporation. Nitrocycle case hardening is claimed to be a simplified and improved method of nitriding steels in dissociated ammonia and is dependent upon "retaining the products of dissociation for regeneration of ammonia, and controlling case characteristics by adjusting the ratio of the original mass of ammonia to surface area."

Ammonia dissociates at the nitriding temperature giving active nitrogen, some of which reacts at the surface of the steel to form nitrides, the rest forming molecular nitrogen, which, in the conventional nitriding process, passes out and is lost : but the dissociation of ammonia is a reversible reaction and in a closed system under pressure a large percentage of the nitrogen of the original ammonia is utilised in the formation of nitrides. The process was previously referred to as "pressure nitriding," but the trade name "nitrocycle" was given to the process because an alternate dissociation and regeneration of ammonia was held to take place. In nitriding the inner surface of tubes or cylinders a measured amount of liquid ammonia, in separate sealed capsules, is introduced into the closed tube. Otherwise, the ammonia is charged as a gas into a closed low-carbon steel retort holding the work to be nitrided, the amount being determined by the pressure. The amount of ammonia required is about 5 grammes per square foot of surface. The nitriding operation is carried out at a temperature between 950 deg. and 1050 deg. Fah. (510 deg. to 565 deg. Cent.) and at a pressure of 200 lb to 800 lb per square inch. The method is applicable to all varieties of nitriding steels. Greater hardness is obtained, depth of case is increased, nitriding times are shortened and ammonia consumption reduced by 90 per cent. Further information about the process and details of its practical operation can be obtained from the Oil Well Supply Company, Ltd., 5, Queen Street, London, E.C.4.

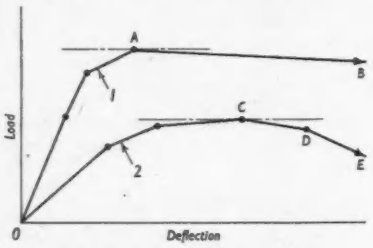
LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

EFFECT OF DISTORTION OF A STIFF-JOINTED FRAME ON ITS PLASTIC COLLAPSE LOAD

SIR,—The article by Professor King and Mr. Jenkins, in your issue of April 13th, on the effect of distortions on plastic collapse loads is most valuable in showing the qualitative results which may be obtained. It is, however, important to realise the exact nature of the solution which is considered. Assuming a shape factor for the members of unity, typical load-deflection relationships for frames up to collapse, taking change of geometry into account, are shown in the sketch. The points *A* and *D* on the two curves correspond to the plastic collapse mechanisms usually assumed to represent the state of collapse, and calculated by the authors. In (1), the corresponding load is the maximum load, whereas in (2), the maximum load



Load / Deflection relationships

occurs at an earlier stage represented by point *C*. Hence the mechanism load may not be the maximum load when deflections are taken into account, although for most structures, the difference, if any, will be slight.

It is necessary to make an important correction to the authors' analysis. While the base stanchion moments in Fig. 3, (*f*) are indeterminate when the deflections are assumed negligible in relation to the dimensions of the structure, one or more of the stanchion feet must be considered fully plastic at collapse when the effect of large deflections is under discussion. In the particular case when $H=0$, it is necessary that $M_A=M_B=-M_p$, not $M_A=M_B=M_p/2$ as assumed by the authors. This will cause the point *G* in Fig. 3 to rise to the value 16, that is, the finite deflections have no effect on the load at which the structure becomes a mechanism. Similar corrections must be made in the solutions represented by Figs. 5, 6 and 7.

The authors are not sufficiently precise over the method of calculating the deflection on the point of collapse. This deflection cannot be found merely by calculating the elastic deformation between adjacent nodal points with full plastic moments unless one of the hinges has not actually deformed, and connects the member considered to a non-rotating foundation or an elastically rigid part of the structure. In general, in order to determine the deflections at collapse, it is necessary to determine which hinge is the last to form; a suitable method has been discussed by P. S. Symonds (Welding Research Supplement, January 1952, discussion of paper on "Welded Continuous Frames—Plastic Design and the Deformation of Structures," by C. H. Yang, L. S. Beedle and B. G. Johnston). No useful quantitative conclusions about the effect of deflections on collapse loads can be reached unless such a full analysis is made.

Finally, it is interesting to note that the load at collapse may be found directly from the work equation, assuming that the deflection at collapse is known. Thus, in Fig. 2(*a*) of the authors' paper, the vertical loads *W* descend a total distance $\theta^2 h/2$, and during an additional deformation $\delta\theta$, this distance increases by $(\theta h)\delta\theta$. Hence the work equation for the incremental deformation $\delta\theta$ becomes

$$6M_p\delta\theta = Hh\delta\theta + 2W(\theta h)\delta\theta$$

giving

$$6M_p = Hh + 2Wh\theta$$

in agreement with equation (15) of the authors' paper. The authors' intermediate collapse mechanisms could be solved in a similar manner, although not so readily. It would, however, be unwise to ascribe much significance to these intermediate mechanisms. It appears from the authors' examples that an envelope obtained from all the straightforward collapse mechanism lines (similar to equation 15) always gives a result on the safe side, the actual error being small.

M. R. HORNE
(Assistant Director of Research)
Dept. of Engineering, University of Cambridge,
April 24th.

PAYMENT BY RESULTS ?

SIR,—I have a suggestion to make which would, if adopted, make unnecessary the continual presenting of wage claims and the threat of redundancy, which is likely to continue as more of industry becomes "automated."

Grant me first that payment by results is the most equitable form of reimbursement for work done. When all work in industry was done by hand, or by means of the simpler machine tools, such as cranes, simple lathes and drills, &c., it might have been argued that payment on a time basis was an accurate gauge to use; but at the present time, when industrial processes are so much more complex and dependent on the growth of automatic mechanisms which bear no relation to human productivity, this form of payment (time basis) is seen to be becoming a less accurate basis for making payment. On the other hand, payment on a quantity basis could never become an unjust method of payment for this automatic age, as it is independent of rate of productivity as expressed in quantity per man-hour.

Grant me further that since redundancy will still be threatened, it ought to be made the policy of Government to institute a basic cost-of-living payment to everyone, without attaching any condition of receipt other than that they should be permanent or semi-permanent residents of this country. The time is now ripe for such a policy to be made. A certain Gertrude Williams, writing in the March 2nd issue, almost pointed this out in her article in which she revealed the existence of the two states of man's inhabitance; as an involuntary member of society (note the choice of adjective) and as a worker. Gertrude Williams pointed out how many different payments were now being made by the Government in respect of one factor or another, all in favour of the family's dependents. It seems strange that though these different parts of the family unit all have free payments, the most important of the lot, the bread-winner, gets no payment at all in respect of himself: it never occurs to anyone that this bread-winner is just as much a dependent as anyone else—on his employer, and stands constantly in danger of "the sack"—"en mass" as it now appears. I suggest that the time is now ripe to provide a system of payments based on the Government's cost-of-living index (or some derivative of this), to be paid to every man, woman and child in the country, regardless of their productive value. This would also simplify, by bringing them all under one head, all the various, superficially unrelated, payments which are now made; they would all be replaced by this one cost-of-living payment, per individual.

Granting me, then, these two facts, I would say that: wages should be made up of these two parts; the Government's cost-of-living grant, which is "dependent on nothing but the fact of citizenship," plus the factory wage, the rate dependent on the skill or quality of the work done, and the amount dependent on the quantity of work done.

MAURICE COLLINSON
Bradford,
May 13th.

HOUSEHOLDS AND EARNERS

SIR,—While there is much to be said for one point of view implicit in your correspondent's (Mr. K. N. Matthews) letter, namely, that it is important that a man should be able to lay claim to a share in the country's capital goods at a relatively early age, his attitude towards the problem of saving is not as reasonable as it might be.

An estimate of the money required to set up a home is a personal one. In deciding the best way to build up a fund one must of necessity take into account current economic facts. That we are living at a time when inflation is proceeding at a rate greater than in the period between the wars has advantages as well as disadvantages. One is that the money value of some capital goods, such as a house, tends to rise as the inflation proceeds: assuming that wages keep more or less in step with rising costs, it becomes progressively easier to pay off a mortgage and a perceptive mortgagee would certainly not, unless there is a penal rate of interest, attempt to discharge a mortgage in ten years. Indeed, a thirty-year term would be preferable.

It is certainly disheartening to try to save and see one's savings devaluate, but even in

these times it is not inevitable. Had Mr. Matthews three years ago invested £200 of his savings in any one of a dozen good-class industrial stocks, it would be worth to-day between £400 and £600, depending on his choice ; at least one of his problems would thus have been solved.

J. F. POLLOCK

Guildford, May 7th.

Literature

Famous Problems and Other Monographs. By F. KLEIN, W. F. SHEPPARD, P. A. MACMAHON and L. J. MORDELL. Chelsea Publishing Company, 552W, 181 Street, New York, 33, N.Y. Price 3 dollars 25 cents.

THERE must be very few who have no knowledge of or no interest in the three classical geometrical problems : the duplication of the cube, the trisection of an angle, the quadrature of the circle. They have been described, and the history of their origin and attempts at solution recounted, in many popular books on mathematics. Professor Klein supplied a mathematical discussion of these three famous problems in a small book, *Famous Problems of Elementary Geometry*, published in German in 1895, and which has itself become a classic. The first English translation by the American mathematicians, Beman and Smith, was published two years later by Ginn and Co. It was also translated into French, Italian and Russian. In 1930 Professor Archibald, of Brown University, produced a second edition, correcting some errors in the first and amplifying with notes. The first monograph of the book under review is a reprint of this edition.

Klein first of all considers the possibility of the construction of algebraic expressions with straight edge and compasses and establishes the criterion that the degree of the expression must be a power of two. This general theorem is then applied in turn to the problems of the duplication of the cube and the trisection of an angle, proving that their geometrical constructions are impossible.

An account is then given of the equally famous, but probably not so well-known, problem : the division of a circle into equal parts. The construction for regular polygons with three, four and five sides—or combinations of these numbers—has been known for some time. It was, however, not until the beginning of the nineteenth century that it became known that polygons could theoretically be constructed by straight edge and compasses with 17, 237, 6537 and larger numbers of sides when Gauss proved the possibility for every prime number of the form $p=2^{2m}+1$. Klein gives a construction for a regular heptadecagon by solving geometrically step by step the algebraic expression : Archibald, in the Notes, gives a construction based entirely on geometrical considerations. To conclude this first part Klein discusses methods of construction by paper folding and by the use of special curves.

Quadrature of the circle is considered in a second part. Trancendental numbers are first discussed and the possibility of squaring the circle by a geometrical construction resolved into one of determining whether π is an algebraic or transcendental number. It is shown how this depends on the famous equation of Euler : $e^{i\pi}=-1$, for the transcendence of π is established by first of all proving that e is a transcendental number. An account is given of historic methods of determining the value of π by means of curves such as the quadratix.

The second monograph, *From Determinant to Tensor*, by W. F. Sheppard, was originally published by Oxford University Press in 1923. This begins with chapters on the elementary theory of determinants ; leads on to consideration of sets and their properties ; and ends with examples of the application of the tensor calculus to the theory of statistics and to relativity.

There is a similarity of treatment in the next monograph, *An Introduction to Combinatory Analysis*, by Major P. A. MacMahon, first published by Cambridge University Press in 1920. This proceeds from the elementary theory of symmetric functions to an exposition on the theory of distribution and partition.

Finally, there is a reprint of *Three Lectures on Fermat's Last Theorem*, by L. J. Mordell, which was delivered at Birbeck College in 1920 and published in the same year by Cambridge University Press. This is another famous mathematical enigma with historical associations. An interesting discussion is given on whether Fermat did or did not prove his theorem ; and there is an account of the various avenues of exploration that mathematicians have taken in order to obtain a proof.

Of these four separate booklets the first and the last are of the greater general interest. The others are more specialised and are for the pure mathematician with a knowledge of more than elementary algebra and analysis. Klein's work on the three geometrical problems, which occupies just under a third of the complete book, deserves special mention. These problems of antiquity are considered in the light of the results of modern mathematics in a clear and interesting manner. The treatment, although mathematical, is sufficiently elementary to appeal to a wide range of readers. It is an important contribution to mathematical literature and its reappearance after a number of years will be welcomed.

These four monographs, each of which deals with an important aspect of mathematics, are unrelated and they have been published together in a single book, according to the editor, entirely for reasons of economy. To quote from the preface, " Anyone who buys the book for the sake of one of the four volumes that it contains will surely find the other three of interest and will consider them to be a worth-while and welcome addition to his library." This opinion is confirmed.

Naval Marine Engineering Practice. H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 25s.

IT is pointed out in the preface that this book has been compiled for the purpose of illustrating and describing the construction, operation and maintenance of machinery for which the engine-room department is responsible in H.M. ships ; it is primarily for use in the training of engine-room artificers and mechanicians. It first appeared in 1952 for official use only, under the title *Marine Engineering Notes for Engine-Room Artificers' and Mechanicians' Training*, but has been brought up to date (1955) by the inclusion of all amendments to the original publication.

The contents are under five basic headings—Boilers, Reciprocating Machinery, Turbines, Auxiliary Machinery and Internal Combustion Engines ; each of these sections is appropriately subdivided into chapters which cover all details of the many components of the machinery to be found in the ships of the Royal Navy. Beyond basic and fundamental facts no attempt is made to deal with the theory and design of marine machinery and it is pointed out that this publication does not supersede the regulations and instructions contained in the *Engineering Manual*. Each section does, however, cover in an extremely concise way points of operation and maintenance.

An outstanding merit of the book is the very large number of clear sectional drawings together with a proportion of isometric illustrations which add greatly to the value of the book as an instructional manual. Naturally it concentrates on naval machinery, but the descriptive work applies equally to Merchant Navy practice, and it should prove a valuable addition to the libraries of all technical schools and colleges where young marine engineers are studying for their Ministry of Transport Certificates. In fact, it is a useful manual for every seagoing engineer irrespective of rank, and in spite of its purely nautical application it forms an admirable textbook of the " descriptive " kind for all students of heat engines.

The detailed work prior to publication of a book of this kind takes a long time, and although the present volume is brought up to date as at 1955, we feel that it does not cover the very latest naval practice owing to the rapid progress in the technical development of naval engineering during the last few years, to meet our defence requirements ; and, of course, we realise that latest naval engineering practice is still under the ban of secrecy.

Metals Handbook, 1955 *Supplement*. Published by the American Society for Metals, 7301, Euclid Avenue, Cleveland 3, Ohio.—THIS, the second supplement to the 1948 edition of the *Metals Handbook*, first appeared as a special issue of *Metal Progress*, August 15, 1955, and its contents were indicated and commented upon under Metallurgical Topics in THE ENGINEER, November 25, 1955, page 764. Now issued as a separate bound volume, it will conveniently take its place on the bookshelves along with the *Handbook* and the 1954 supplement. Most of the nineteen articles contained in this supplement either substantially add to or entirely supersede the corresponding articles which appeared in the 1948 edition or the 1954 supplement. New subjects dealt with are the Selection of Sheet Steel for Formability, the Selection of Material for Press Forming Dies, and the Surface Finish of Metals. There is an excellent index.

The usefulness of the *Metals Handbook*, which is very widely recognised by metallurgists and users of metals, is greatly enhanced by the issue of these supplements, bringing up-to-date information and introducing new subjects of current interest. No user of the *Handbook* can afford to do without the supplements.

Books Received

Atoms and the Universe. By G. O. Jones, J. Rotblat and G. J. Whitrow. Eyre and Spottiswoode (Publishers), Ltd., 15, Bedford Street, Strand, London, W.C.2. Price 25s.

Productivity in Hot Dip Galvanising—A Study Made in the United States of America. By A. G. Northcott. Zinc Development Association, 34, Berkeley Square, London, W.1. Price 7s. 6d.

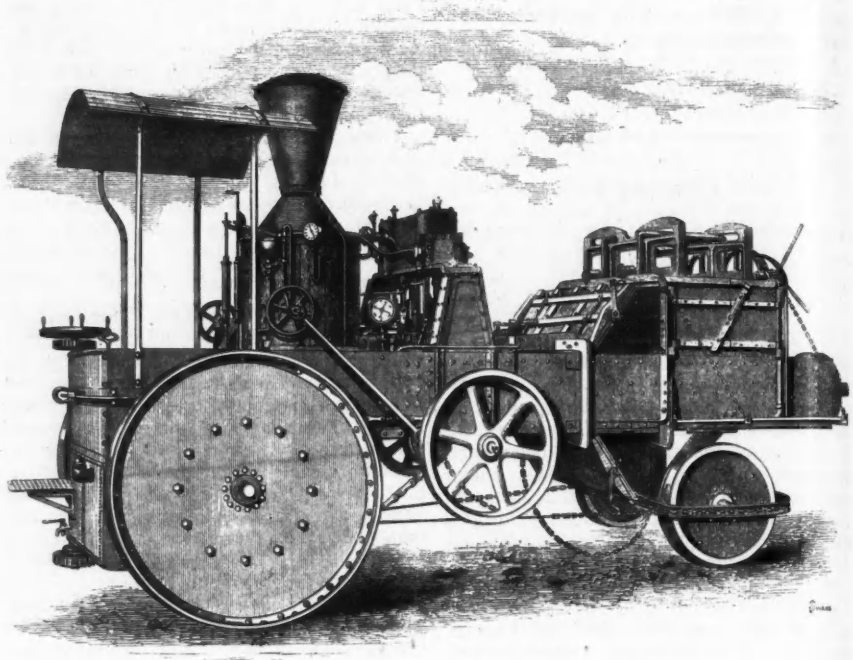
Time Measurement : Part II, Descriptive Catalogue. Third edition. By The Science Museum. H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 6s.

Forest Products Special Report, No. II : The Blunting of Woodcutting Edges. By H. J. Endersby. H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 2s.

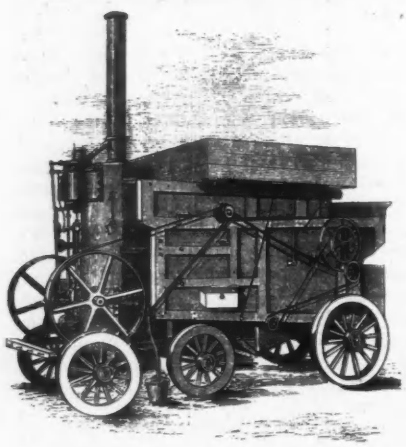
Britten's Old Clocks and Watches and Their Makers. Seventh edition. By G. H. Baillie, C. Clutton and C. A. Ilbert. E. and F. Spon, Ltd., 15, Bedford Street, Strand, London, W.C.2. Price 147s.

ENGRAVINGS OF 1868

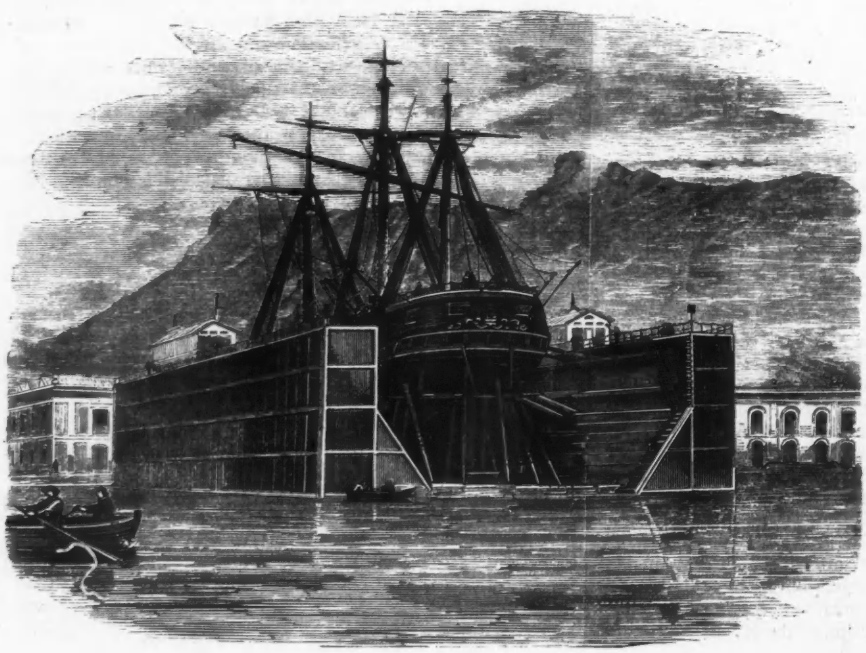
The locomotive cotton press, which is shown in the right-hand engraving, was constructed, for use in India, by Appleby Brothers, of Leicester. A description of it was given in our issue of October 2, 1868. The equipment, consisting of a traction engine and cotton press combined on one frame, was invented by a Mr. Wilson, to overcome the difficulties of transporting unpressed cotton. The press appears in many respects similar in construction and operation to hay and straw balers of more recent times. Our description says that "the cotton is compressed into one-seventh of its original bulk, and, allowing for the expansion which takes place when it is withdrawn, it occupies in the finished bale 4ft by 1ft 9in by 1ft 9in." There are no details of the engine, beyond the comment that "the self-propelling gear is very simple," and that "arrangements are made to drive with a strap a second and third press, if necessary, as the engine is sufficiently powerful for the work."

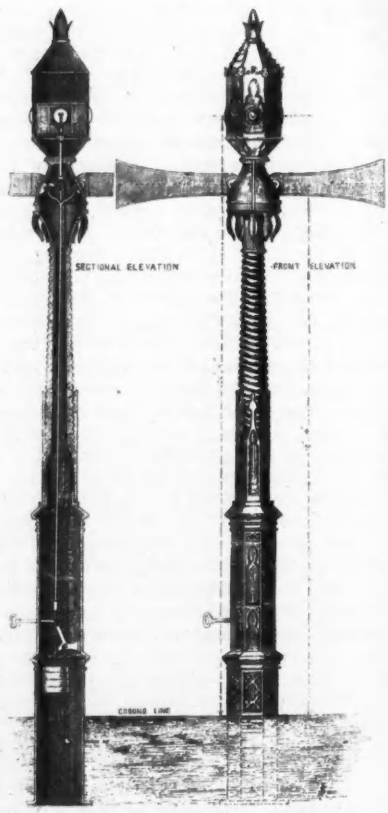


Below there is reproduced, from our issue of November 27, 1868, an engraving illustrating a combined engine and threshing machine which was built by T. Garvie and Co., Aberdeen. The boiler, it was stated, was "made of Lowmoor iron throughout" and had a working pressure of 60 lb to 80 lb; the speed of the engine was 205 r.p.m.



The engraving below shows a floating dock for Carthagena, which was built by J. and G. Rennie, and described in our issue of September 11, 1868. The principal dimensions were quoted as: length, 320ft; breadth, 105ft; inside depth, 36·6ft, and inside breadth, 79ft. The weight of the dock, with its machinery, was about 4500 tons, and it was capable of docking a ship of 6600 tons. The floor of the basement, our description records, was of 3in teak. It is added that "a pair of high-pressure engines of the combined power of twenty-four horses are placed on the top of each side of the dock, near the centre, to work a set of pumps (four each side) for emptying the basement."





The "handsome semaphore signal post," shown by the engraving above, was erected at Bridge Street, Westminster, in 1868, to "supply substitutes for the policeman's arm" in controlling the "streams of vehicles." A description of this traffic signal, in our issue of December 11, 1868, says that it was the work of Messrs. Saxby and Farmer. "By a light pull at a horizontal bar," a policeman was "enabled to raise four arms at a height of 18ft above the ground."

Motor Ship "Scillonian"

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

THE Scilly Isles, outposts of Great Britain situated well into the Atlantic, differ in many respects from other islands that surround our coast in that they are scattered and small, sparse in population and practically devoid of manufacturing industries. An attempt was made to develop a trade in early potatoes, but the Channel Islands being nearer the mainland proved strong competitors and the trade lapsed, but has since been developed again. The main products are early flowers, which provide occupation from December to May, after which period every encouragement is given to fostering an extensive tourist trade. To maintain a remunerative steamer service has always been a problem largely overcome by the islanders themselves, who have ensured a regular service being maintained between Hugh Town, the capital of St. Marys, the principal island, and Penzance.

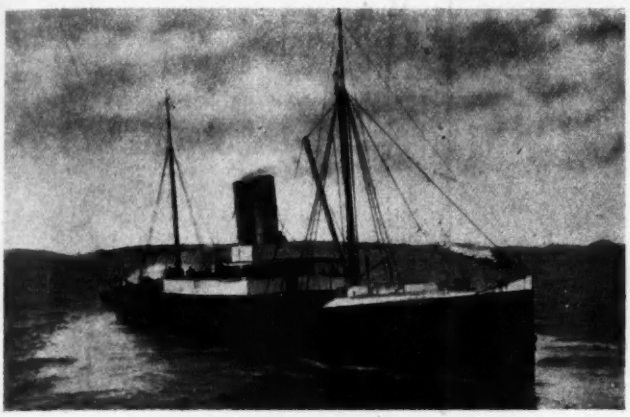


Fig. 1—Steamship "Lyonnesse" (1889)

The West Cornwall Steamship Company for a considerable time operated with moderate success the small steamer "Lyonnesse," a sturdy little craft with two yellow black-capped funnels and two pole masts (Fig. 1). Her principal dimensions were: length, 170ft; breadth, 25·1ft; depth, 10·4ft; tonnage, 382 gross. She was driven by a single-screw operated by triple-expansion engines, with cylinders 22in, 32in and 52in diameter, and a stroke of 30in. Built by Harvey and Co., of Hayle, near St. Ives, Cornwall, in 1889, for some thirty-seven years she made the passage regularly even though often having to contend with Atlantic storms. When her day was evidently drawing to its close it appeared as if the service might have to be abandoned, but the Scillonians themselves, with commendable enterprise, came to the rescue and provided the necessary capital for a more modern steamer to be built. An order was placed with the Ailsa Shipbuilding Company, Ltd., of Troon, for a modern steamer, and "Scillonian" came on service in 1926. From the illustration (Fig. 3) it will be seen that she had a pleasing yacht-like outline, but actually she was a sturdy craft and a clean sea boat well able to negotiate the exposed waters between her two ports, and her passenger accommodation was a great improvement on that found in her predecessor. Her principal dimensions are: length, 170·7ft; breadth, 28·7ft; depth, 10·8ft; tonnage, 435 gross. She is driven by triple-expansion engines with cylinders 13·5in, 21in and 35in diameter, with a stroke of 26in. Steam is supplied by a single-ended boiler at a pressure of 180 lb per square inch. Her corrugated furnaces have a grate area of 64 square feet and a heating surface of 2171 square feet. The tail shaft is fitted with continuous liner throughout the length of the stern tube.

The Isles of Scilly Steamship Company realised that it was time for a new vessel to be built, and again the islanders played their part by subscribing 90 per cent of the £250,000 required for the ship that was ordered from John I. Thornycroft and Co., Ltd., of Woolston. It was decided to give her the name that had become popular, and as "Scillonian" she was launched by the Duchess of Gloucester on November 15th, last year. Incidentally, the former "Scillonian" has been sold and renamed "Penninis" and has probably many years of useful life still before her. If perhaps not so pleasing in appearance as her predecessor "Scillonian" (Fig. 2) has a modern "look" and is larger than the former ships, the principal dimensions being: length, overall, 208ft 6in, at waterline, 200ft; moulded breadth, 30ft 9in; depth to main deck, 13ft 9in; depth to promenade deck, 21ft 3in; tonnage, 930 gross. She has been built to Lloyd's Class 100A for channel service, and carries a Ministry of Transport certificate Class II A.

The main propelling machinery has been supplied by Ruston and Hornsby Ltd., Lincoln, and consists of two Mark 6 VGBXM six-cylinder, vertical pressure-charged, four-stroke cycle, airless-injection, cold-starting, uni-directional marine propulsion diesel engines, arranged for outboard turning, each coupled to an oil-operated reverse and reduction gear supplied by Modern Wheel Drive Company, Ltd. Each engine has cylinders with a bore of 12·5in and a stroke of 15in. The rated brake horsepower is 720, the engine speed 430 r.p.m., and that of the propeller shaft 222 r.p.m., the shaft horsepower being 670. A speed of 15·5 knots was obtained on her trials, and it is hoped to be able to improve considerably on the three and a half hours at present allowed for the passage between the Scilly Isles and the mainland, enabling the day tourist to have nearly an hour longer in the Isles.

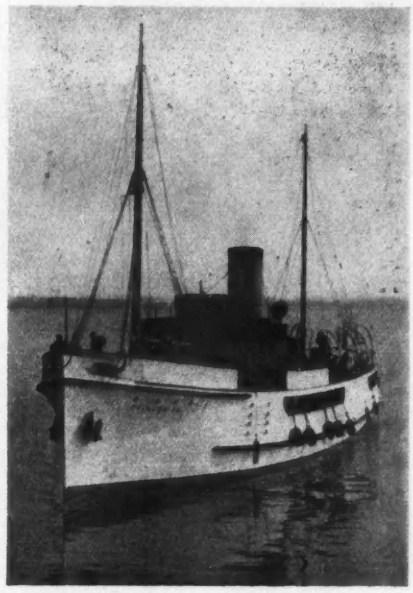


Fig. 3—Steamship "Scillonian" (1926)

The auxiliary machinery (Fig. 5) consists of two 35kW, 220/235V diesel generating sets, one 35kW set for harbour use, and one 10kW set for deck emergency use. In addition to an air compressor driven from the main engine there is also a diesel-driven compressor set. Among other equipment may be mentioned two bilge and general service electrically driven reciprocating pumps, a lubricating oil standby pump, a fuel oil transfer pump, a lubricating oil purifier, a heating and hot water boiler with automatic oil firing unit and 15-gallon oil fuel tank, an automatic fire sprinkler system

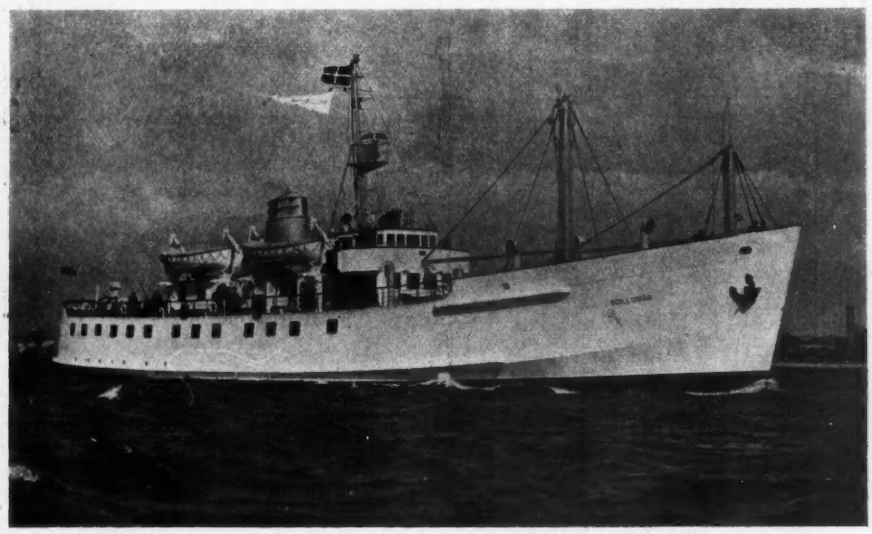


Fig. 2—Motor Ship "Scillonian" (1956)

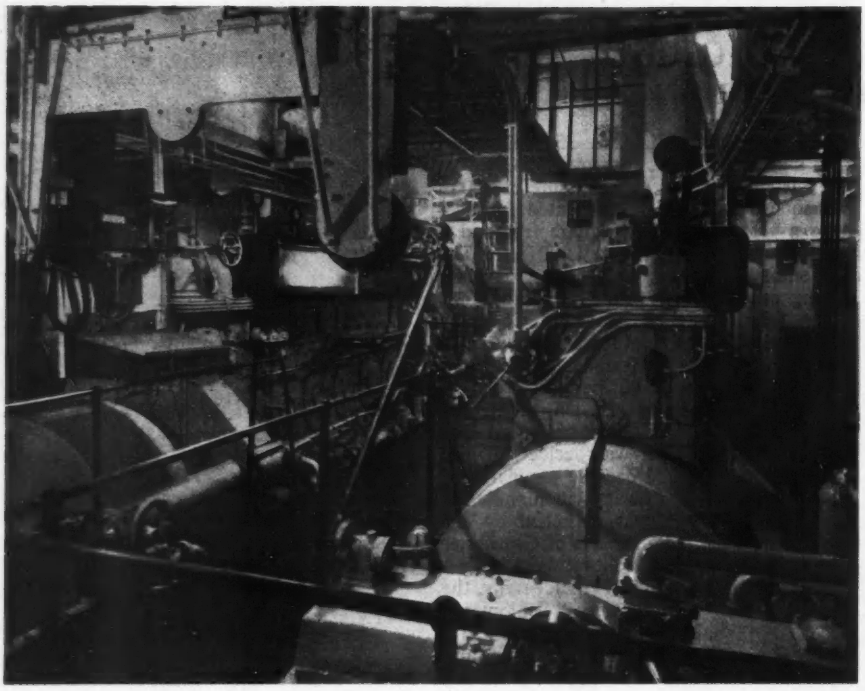


Fig. 4—Main engines, looking forward

with 600-gallon tank. The main switchboard was supplied by the shipbuilders, as also was an auxiliary switchboard in the deck generating room. The Ruston main engines (Fig. 4) work on a closed fresh water cooling system, the necessary Serck heat exchangers being fitted. The main engine controls are centralised inboard at the aft end of the engines. The line shafting runs in "Michell" plummer blocks and the propeller shafts run in oil bath stern tubes with "Cedervall" glands fitted at both ends, inner and outer. The propellers themselves were designed and manufactured by the shipbuilders. The ship is fitted with a specially designed Thornycroft funnel in which are located the main engine silencers, the secondary silencers and the compressor exhaust. A foam fire-fighting equipment has been installed.

Two large holds and 'tween decks situated in the fore part of the vessel are available for the carriage of cargo, giving a total capacity of 26,000 cubic feet. The holds are worked by one derrick to each hold, operated by combined slewing and hoisting winches, the after derrick and winch being capable of handling 6-ton loads, and the forward winch 3-ton loads. Large cargo doors fitted in the shell to port and to starboard 'tween decks are provided to facilitate loading by hand. The electric and hand hydraulic steering gear is operated from the bridge by "Hyland" bridge telemotor standard, and from the emergency position aft by hand hydraulic standard. The ship is equipped with a Marconi "Quo Vadis" radar and Marconi radio equipment, including ship-to-shore telephone facilities.

Accommodation is provided for 500 passengers and a crew of fourteen. The deck arrangement is as follows :—On the bridge deck the wheel-house is situated and the captain's cabin and office. There are also four lifeboats, while, in addition, on other decks are a number of buoyant seats. On the promenade deck forward is a pleasant observation lounge entered from both sides of the deck. In it are upholstered tubular chairs, and there are large windows ; entered from it astern is a bar lounge furnished with upholstered settees and tubular chairs ; in the bar is a bottle-cooling cabinet and ice-making facilities. Coming down to the main deck astern is found a pleasant tea room,

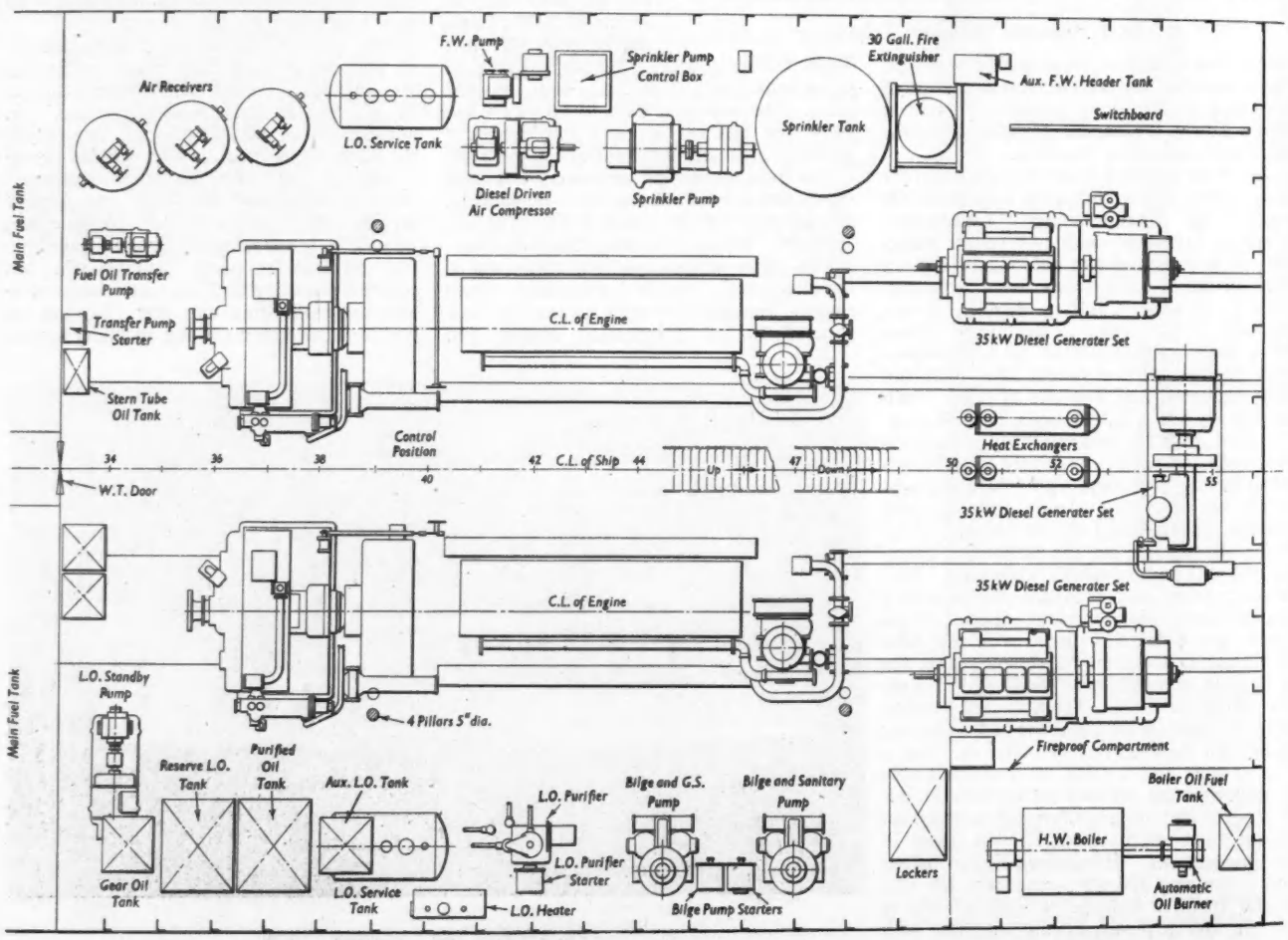


Fig. 5—General arrangement of engine-room machinery

with settees, chairs and tables, and served from a pantry equipped with electrically heated urns for tea, coffee and milk, and a cooling cupboard for storing perishable foods. On this deck also are the cabins for the mate, chief and second engineers, and purser, and the officers' mess. Adjacent to the engine casing is the galley, in which the range supplied by the Carron Company is of the oil-fired type. A wide stairway leads from the tea room to the lower deck, towards the stern of which is a spacious saloon furnished with settees arranged in bays. Further astern are the quarters for the crew, being two two-berth cabins and one three-berth, and also a crew's mess room.

Undoubtedly the new "Scillonian" is a great advance on any previous vessel serving the Scilly Isles, being better equipped and more comfortable. She sailed from Southampton for the Scilly Isles direct on Saturday, March 24th, to begin her regular sailings from the Isles to Penzance, on Monday, the 26th.

Failure of Concrete Under Compound Stress

By A. J. HARRIS, B.Sc. (Eng.), M.I.C.E.*

We reproduce here abstracts from a paper presented at the Symposium on the Strength of Concrete Structures, organised by the Cement and Concrete Association. The paper describes a new theory of rupture of concrete, in which concepts are applied which are more common in the theory of soil mechanics; the two parameters which express the strength of concrete in this theory are the cohesion and the angle of internal friction.

THE difficulties of predicting the rupture strength of concrete under any but the simplest of states of stress arise from the following factors :—

(1) Methods of analysis hitherto developed have been confined to elastic analysis, of which the hypotheses are irrelevant to the mechanics of rupture. Mohr's circle, for example, while rigorously exact in the elastic zone, is of little use in predicting either the value of a rupture load or even the direction in which failure will be produced by such a load.

(2) There is in any case no parameter hereto available capable of expressing the strength of concrete. The most commonly used test, the crushing test, is very far from serving this purpose, since it measures strength under what is in fact a singularly complicated type of rupture and one which very rarely occurs in a structure in anything resembling the same form.

The theory discussed below has been formulated and developed with considerable subtlety by Coüard in France and is an extension of a theory first applied by him to soil mechanics, where it would seem to have filled in certain of the lacunæ in current theory.

The exposition is necessarily of a somewhat hypothetical nature, in that it is relatively rarely that tests have been carried out in the past in such a way that all the conditions relevant to analysis by this theory were known. Nevertheless, it is hoped that sufficient correspondence with experimental facts will emerge to justify further investigation. In fairness to Coüard it must be said that the exposition which follows is by no means at all points identical with his own.

Description of Theory

The two basic parameters are the cohesion c of the concrete and its angle of internal friction ϕ.

Cohesion is the resistance offered either to the sliding of two planes or to the separation of two planes, and is proportional to the surface area of the planes. Cohesion is basically the same phenomenon as that referred to as "tensile strength," but may have a different numerical value due to the special circumstances under which direct measurements of the latter are usually made.

The angle of internal friction ϕ is that angle whose tangent relates to the resistance offered to the sliding of two planes to the normal stress between them.

It will be seen that this friction effect may be positive if the planes are under compression, when it is added to the cohesion, whilst it may be negative if the planes are under tension, when it is subtracted from the cohesion.

A typical analysis assumes that rupture is about to occur and that a certain plane is in equilibrium under the tangential loads and the frictional and cohesive reactions; the expression for the load is differentiated with respect to the angle of the plane, whereby the angle of the plane producing minimum load is obtained. This will be the angle of rupture and the corresponding load will be the rupture load.

* Consulting Engineer

Applications of the Theory

Crushing Failure of a Prism.—Assume a prism of breadth b and unit thickness to be submitted to a longitudinal load stress p and a transverse restraining stress p_0 (Fig. 1). Let β be the angle of inclination of the rupture plane to the axis of the prism; the characteristics of the material are the cohesion c and the angle of friction ϕ. Then the forces on the rupture plane due to the load p are given by

$$N_p = pb \sin \beta,$$
$$T_p = pb \cos \beta,$$

and the forces due to the transverse stress p_0 are given by

$$N_0 = p_0 b \cot \beta \cos \beta,$$
$$T_0 = p_0 b \cot \beta \sin \beta = p_0 b \cos \beta.$$

The cohesive force along the plane is given by

$$F = \frac{cb}{\sin \beta}.$$

Then resolving along the plane,

$$T_p - T_0 = (N_p + N_0) \tan \phi + F.$$

This gives, by substitution :

$$pb \cos \beta - p_0 b \cos \beta = pb \sin \beta \tan \phi + p_0 b \cot \beta \cos \beta \tan \phi + \frac{cb}{\sin \beta},$$

whence

$$p = \frac{c}{\sin \beta \cos \beta - \sin^2 \beta \tan \phi} + \frac{p_0 (\sin \beta + \cos \beta \tan \phi)}{\sin \beta - \sin \beta \tan \beta \tan \phi}.$$

Differentiating with respect to β, we obtain

$$\frac{dp}{d\beta} = \frac{(c + p_0 \tan \phi)(\sin 2\beta \tan \phi - \cos 2\beta)}{\sin^2 \beta \cos^2 \beta (1 - \tan \beta \tan \phi)^2},$$

which is equal to zero when

$$\beta = 45 \text{ deg.} \pm \phi/2,$$

which is Coulomb's law, being independent of p_0 and c.

If we assume that $\phi = 37$ deg., a commonly accepted figure for concrete, we obtain the following results :—

$\beta = 26 \cdot 5$ deg. (this is in good accordance with practice)

$$p = 4c + 4 \cdot 04\, p_0.$$

[The paper then gives failure analyses for a cylinder and a cube, and discusses these results in relation to axial loading and axial loading combined with transverse stress.]

Compression Failure by Longitudinal Splitting : Poisson's Ratio.—The type of failure in which the specimen is split by planes of cleavage parallel to the axis of loading is not unknown, distinguishing this case from the typical failure of a cylinder where longitudinal cracks certainly appear, but are found to be caused by the bursting effect of the opposed cones. Such failures of the paralleled types as have come to the writer's notice, however, have all been associated with a capping device such as rubber sheeting, which not only eliminated friction, which was the intention, but actually exerted bursting pressure on the end of the specimen.

Nevertheless, this form of failure is known with other materials, notably stone (even with no noticeable bedding planes)—and it is worth while asking if a reason can be found for its rarity in concrete testing.

The general sequence of strains in concrete under compression is well known, and accords with the theory that concrete is constituted of an assembly of hard grains united by an open skeleton of hydrated crystals, in the interstices of which lies a complex of vapour, water and hydrates in equilibrium. The following stages occur :—

(1) Deformation of aggregate and cementing skeleton without sliding. This deformation causes changes of volume and shape in the intervening interstices which result in the familiar phenomena of deferred and moisture-sensitive strains. This stage is normally associated with negligible transverse strains.

(2) Sliding movements between particles of aggregate tending to reduce the volume of voids and increase the density. Transverse strains begin to be appreciable. Deformation being associated with sliding in this stage, the onset of stage (2) is the beginning of non-reversible strains; the reversibility of the deferred strains, or creep, noted in stage (1), has been observed by some experimenters. This stage is greatly prolonged by the presence of spiral binding.

(3) A series of local sliding failures in which cohesion is overcome; these failures become generalised and result in an eventual plane of rupture. This phase of disaggregation is associated with an increase of apparent volume, the final volume just prior to rupture being on occasion greater than that at the commencement of test.

It seems evident that as long as sliding deformation takes place, rupture by planes parallel to the axis of load cannot occur. Under what circumstances, then, can such rupture occur ?

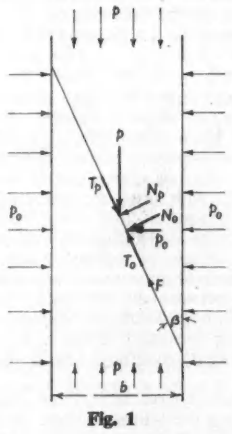


Fig. 1

It looks as if it can only happen if stage (2) does not exist, and there are two ways in which this may happen :

(1) Rupture occurs before stage (2) is reached; this can only occur by collapse of the grains themselves, which must thus yield before the cementing skeleton does.

(2) The solid is fully compacted at the beginning of the test and no inter-granular movement is possible; the grains under load expand transversely by Poisson's effect and destroy cementation solely by transverse strain causing local axial cracks, without any sliding movement at all.

If these reasons be sound, this type of failure

would not be expected with concrete since the aggregate is almost always stronger than the cementing skeleton and compaction of the latter is usually low.

It is evident that, with such a material, Poisson's ratio will necessarily be a highly contingent characteristic varying widely with compaction and the state of equilibrium in the voids.

[The next section of the paper examines tensile and shear failures.]

Values of Parameters

Cohesion c.—It has been suggested that the properties referred to as cohesion and tensile strength are basically identical; on the other hand, the expressions obtained for the strength of concrete in terms of c suggest that the value of c would be appreciably larger than that given by any direct measurement of tensile strength.

It is known that there is considerable dispersion in the results of direct and bending tensile tests; it seems reasonable to suppose that this dispersion is caused by the fortuitous occurrence of local weaknesses and stress concentrations, factors which would have less effect in reducing the cohesive resistance to the sliding of two planes. We may suppose in consequence that cohesion is numerically larger than tensile strength as normally measured; a factor lying between 1·5 and 2 would reconcile most of the theoretical figures with common experience.

Two factors appear likely to affect the value of cohesion.

(1) Density of cementing medium. The more tightly packed the crystal structure, the more uniform and the larger would one expect the cohesion to be. Note that it is the cementing medium to which reference is made; it is improbable that greater or less compaction of the coarse aggregate would directly affect cohesion. Normal vibration has little effect on the compaction of the cementing medium.

(2) Recovery from loading. After heavy straining, it is likely that cohesion is broken down fairly widely throughout the mass; we know that after a lapse of time, cohesion can be re-established. The time taken for such re-establishment is evidently a factor in the sensitivity of concrete to rate of loading.

Angle of Internal Friction ϕ.—The work of Bowden on surface friction has cast much light on the mechanics of this phenomenon; friction in a mass, however, still remains obscure and it is difficult to form a clear picture of its mechanism; much more so to measure its value directly. The value of ϕ is in consequence only to be determined by processes of induction.

The sources of information available at the moment are the following:—

(1) Tri-axial tests, evaluation of k in expression

$$p=f_c+kp_o.$$

(2) Simple and tri-axial crushing tests; measurement of angle of rupture. The tri-axial tests have given three groups of values: (1) tests on once-loaded bound cylinders, giving consistent values of approximately 38 deg. This value recurs with tests on concretes of widely varying composition and basic strength. (2) Tests on twice-loaded bound cylinders, giving consistent values of approximately 42 deg., assuming normal increase of basic strength over the period between the two tests. (3) Tests on cylinders with hydraulically applied transverse stress, giving consistent values of approximately 28 deg. at twenty-eight days and 29 deg. at ninety days.

An attempt to reconcile these results would proceed along the following lines. In the bound cylinders, the transverse stress is a reaction created by the strain of the concrete; it thus acts only after the concrete has been heavily deformed and, in the process, compacted. In the latter group tests, however, the transverse stress is applied independently and positively and one would expect the strains to be smaller. In fact, with a concrete of 50 per cent higher crushing strength, these tests gave longitudinal strains at rupture which were of the order of only 20 per cent of those measured in bound cylinders.

By analogy with soil mechanics, one would expect the coefficient of friction of concrete to increase with its compaction; it may therefore be that the bound cylinders give a limiting value only attained after extensive deformation and compaction of the concrete. If this were so, the value of ϕ for concrete not "strain-compacted" would be lower, and the value of 28 deg. might be that appropriate to this somewhat mediocre concrete of approximately 3600 lb per square inch at twenty-eight days.

The increase of ϕ noted by the writer on retesting certain bound cylinders may in fact be only apparent; the increase in strength could be explained by a considerable reduction in cohesion during the course of the tests when the load was carried straight to rupture, the release of load just prior to rupture followed by a period of rest allowing the cohesion to re-establish itself.

A somewhat more fanciful hypothesis could be built on Bowden's association of friction effects with local bearing areas of intense heat. On this basis one might claim that the period of repose of the cylinder was accompanied by a dissipation of the hot spots caused during the first loading, with a consequently higher coefficient of friction under the second loading. In simpler language, the difference would be that between dynamic friction and static friction. In all probability, both explanations apply.

It is encouraging to note that the values of ϕ deduced from these considerations are generally in good agreement with those deduced from the angle of rupture.

Vertical Cylindrical Fluid Heating Furnaces

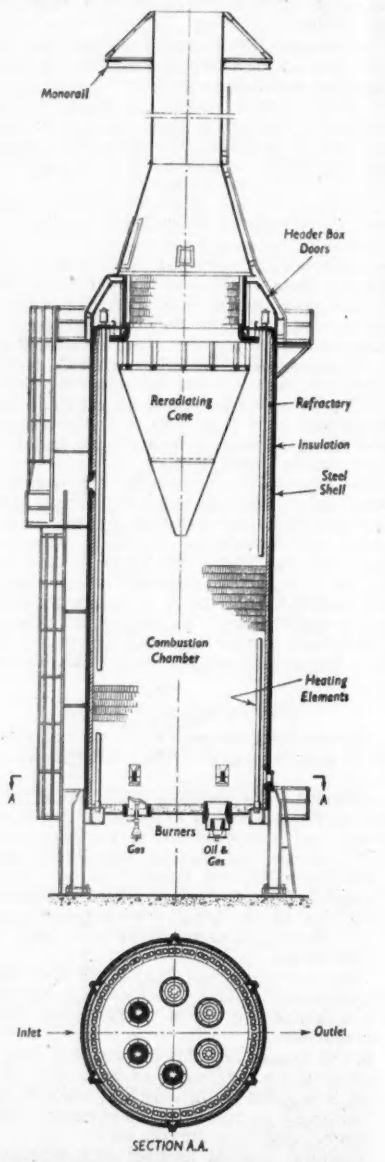
Heating furnaces of vertical cylindrical design are extensively used in oil refineries and chemical plants and have wide applications in other industries. These units have burners fitted in the base and a re-radiating cone at the upper end of the furnace, and can be designed for heat absorption rates ranging from 150,000 *to* 150 *million B.Th.U. per hour.*

THE years since the war have seen considerable changes in the pattern of development of the refining of oil due to the pressure of economic forces, the pressing need to reduce the "dollar content" of the oil, and the new policy of the oil companies to build refineries at home rather than near the source of supply. The expansion of the refining programme and the programme for the increased production of oil called for a corresponding expansion in the equipment manufacturing industry. This has led, again with the emphasis upon saving dollars, to the manufacture of many items of American equipment under licence by British companies.

The "Iso-Flow" furnace, which has been evolved by the Petro-Chem Development Company Inc., of New York, is now being built in this country under licence by Birwelco, Ltd., Chester Street, Birmingham, 6. These fluid heating furnaces are of vertical cylindrical design and are widely used in oil refineries and chemical plants, and have been developed from the earlier forms of vertical cylindrical furnaces which have been employed for many years. They have a wide variety of applications outside as well as inside the oil industry; they are used for heating crude oil for vacuum distillation, evaporating and superheating oil vapours for catalytic cracking, heating lubricating oils and solvents, superheating high and low-temperature steam, heating bitumen products for handling purposes, heating transfer mediums such as "Dowtherm," various purposes including steam generation, and the heating of air for jet engine tests, and for use in wind tunnels. The furnaces can be designed for heat absorption rates from as low as 150,000 B.Th.U. per hour up to 150 million B.Th.U. per hour, and even higher.

The box heater is being gradually superseded by the cylindrical furnace because of its greater efficiency; efficiencies up to about 87 per cent are claimed as being possible, which largely stem from the more uniform heat absorption rates inherent in the design. Early designs which attained high efficiency placed the burner at the top and a refractory cone at the base, and incorporated air heaters, but the design prepared by the Petro-Chem Development Company, Inc. reverses this arrangement. The burners are fitted in the base, and a heat-resisting cone of alloy steel is located at the top of the combustion chamber, natural draught being employed to sustain combustion. Where requirements call for a high degree of efficiency, air heaters and forced draught are incorporated in the design.

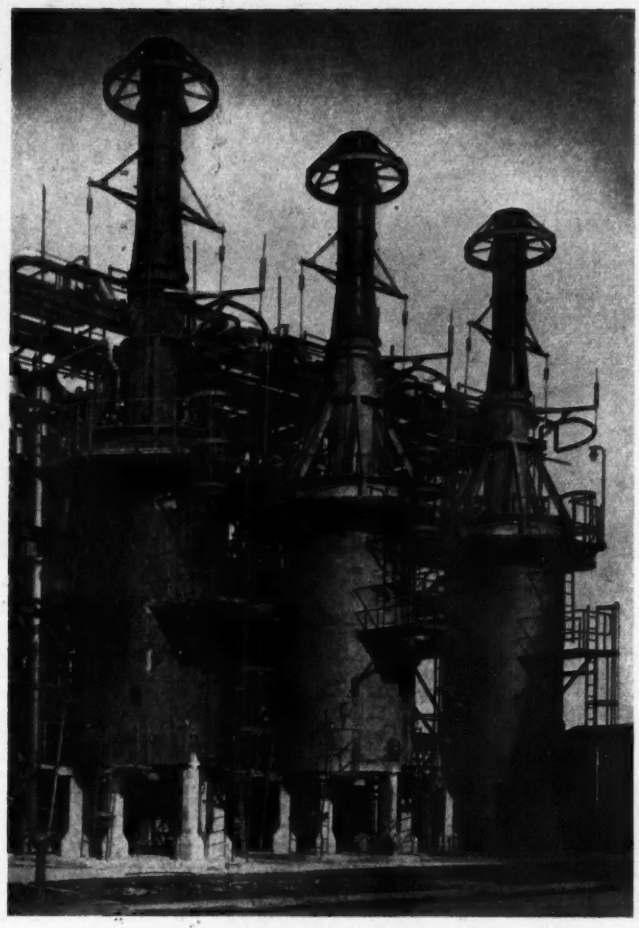
Owing to the large number of variables which have to be satisfied in each furnace, there is no standard design, each one being tailor-made to suit the duty demanded. However, the heater is adaptable and the various components can be designed to meet a wide range of requirements and final temperature imposed by the particular liquid to be heated. Indeed, the time/temperature curve largely governs the basic design which, in



Vertical section showing details of an all-radiant furnace

turn, is dependent upon knowledge of the process aided by theory and service data gained from experience. In designing a furnace, account has to be taken of the gravity, molecular weight and viscosity of the charge, the charge rate, inlet and outlet pressures and temperatures, together with the maximum permitted pressure drop and the heat absorption duty.

Apart from the question of construction to individual requirements, all the furnaces are divided into three groups, these being : (*a*) all-radiant where efficiency is not of paramount importance ; (*b*) the radiant furnace incorporating an integral extended-surface convection section to provide high efficiency in association with a moderate fluid outlet temperature, and (*c*) the radiant design, having a separate extended-surface convection section, which is used to give high efficiency where the temperature at the inlet is relatively low while that at the outlet is relatively high. Our line drawing shows the general arrangement of the all-radiant furnace. In all three groups the radiant zones are practically identical, and the structures are designed so that all parts are free to expand vertically or circumferentially. The "Iso-Flow" design consists of an upright cylindrical steel structure surmounted by an integral self-supporting stack; practically the whole of the steelwork is prefabricated by welding. At the base of the structure, which is carried on supporting legs, is the burner floor, of fabricated steel plate, which incorporates the bottom header box and the burners, and is filled with insulating concrete. The casing shell consists of thin mild steel plate with an inside layer of rock wool insulation, and lined with lightweight high-efficiency insulating refractory bricks. Suspended from the upper end of the combustion chamber by hanger rods from a refractory arch is an inverted cone, of heat-resisting steel, which effects an even distribution of radiant heat and increases the velocity of the flue gases at a point where their temperature is decreasing. At the top of the furnace is an annulus forming the top header box which is fitted with removable steel cover plates. The heat release per cubic foot of combustion space has an approximate range of 10,000 to 20,000 B.Th.U. per hour, with 15,000 B.Th.U. per hour being a good average. Both header boxes and the combustion chamber are equipped with steam smothering connections.



Three vertical cylindrical heating furnaces, each having a heat absorption rate of 5,340,000 B.Th.U. per hour

Firing of the furnace can be by either gas, oil, or combination burners, all of which may be operated independently. There are three forms of gas burner : (i) the aspirating design, which uses the kinetic energy resulting from the expansion of the gas fuel to aspirate and mix combustion air ; (ii) the raw gas unit which takes gas fuel at control pressure without premixing of combustion air, and (iii) the directional aspirating burner. The first-named burner is flexible and gives a short flame length with good flame pattern, while the second burner has a good turn-down ratio and can operate at low pressures. In the third pattern, the burners can be set so that the post-combustion gases scrub the tubes, so increasing the convection transfer rate, and also can be adjusted to give control of the temperatures of the various passes.

Oil burners are also available in three general designs. There is the steam atomising burner, which employs the kinetic energy of the steam to atomise the fuel oil, which should have a temperature ranging from 220 deg. to 375 deg. Fah. at the burner, depending upon the grade of fuel. Steam at 100 lb per square inch gauge is required, preferably with about 50 deg. Fah. superheat. Where steam is not available, an air atomising burner can be fitted, and there is also available a mechanical atomising burner. All burners have separate means for controlling the primary and secondary air. This flexibility permits a variation of the heating curve and provides for uniform heat intensity over the length of the heating elements. Combination gas/oil burners are frequently used.

Around the periphery of the furnace are arranged vertical tubular heating elements which are connected in series at top and bottom to give a continuous flow to the charge. Chrome-molybdenum steel is the material generally used for the tubes, which are of a diameter and wall thickness to suit the charge and the furnace duty. Three forms of headers are in general use, namely, the 180 deg. welded " U " bend, the two-hole header and the Petro-Chem " Y " header, and different combinations of headers are used to suit conditions. The tubes, which are welded to or rolled into the headers, act as columns, being supported at the base and guided at the top by removable segmental tube sheets. Cleaning of the tubes is carried out from the top platform and removal for inspection, maintenance, or renewal is effected by lifting tackle carried on a monorail fitted at the top of the stack. The arrangement of the tubes affords almost complete cover to the casing walls, so that the temperature of the refractory lining is kept low, thus minimising maintenance ; the radiation losses to atmosphere are small, a maximum of 2 per cent being claimed. The number of passes and the corresponding number of inlet and outlet connections are arranged to suit the product, there being exactly the same number of tubes and headers in each pass so that the travel and pressure drop in each section are the same.

Over the lower part of their length the tubes are subjected to a controlled amount of radiant heat through the medium of burner control, while the upper sections are subjected to a combination of direct radiant, secondary radiant, and convection heat. In certain instances the convection surface is augmented by the addition of fins over a defined length in order to maintain a consistent heat absorption rate. As already mentioned, the heat-resisting cone at the top of the furnace assists in maintaining the even distribution of radiant heat, and it also diverts some of the gases behind the tubes where the gases, owing to their lower temperature, descend and so lower the refractory wall temperature by convection. It is essential that the flame should not impinge directly on the tip of the cone, in order to ensure adequate life and performance of the material, and the flame length should not exceed two-thirds of the distance from the burner floor to cone. The arrangement of tubes and cone, ensures that the variation of the heat absorption rate is not more than 10 per cent from the designed duty. Thus, if this latter amount is 10,000 B.Th.U. per square foot, then the heat absorption rate at the centre of the tube, halfway between top and bottom headers will be about 11,000 B.Th.U., while at the bottom and at the top the rate will be approximately 9000 B.Th.U.

With the base of the furnace above ground level the foundations are automatically air cooled: the airtight construction of the furnace casing precludes any chance of air infiltration, so that combustion takes place with the minimum of excess air. However, for normal operation this is generally in the range of 40 per cent excess air. The furnaces described do not operate under pressure, and a negative pressure at the upper end of the convection section can be used to draw in outside air at the base of the stack to cool the steel structure and header box, and also to cool the flue gases so that insulation of the stack is not required.

Development is still, as always, continuing, and radical changes may be expected in the largest types if the examples being built in some of the world's largest refineries enjoy the success anticipated.

The photograph, reproduced herewith, illustrates a battery of three vertical cylindrical heating furnaces which have been built by Birwelco, Ltd., for service with a chemical company. These particular units have a base diameter of 11ft and have an overall height of approximately 60ft. The furnaces are required to superheat steam and each has a heat absorption capacity of over 5,000,000 B.Th.U. per hour.

POST-FORMING PLASTIC LAMINATE.—A variant of the current grade of " Formica " laminated plastic has been developed by Thomas De La Rue and Co., Ltd. This material, which is supplied in ⅛in sheets, becomes plastic for a limited time when heated to 325 deg. Fah., and in that condition can be bent round cylinders as small as 3in diameter. Once this time has expired the material is again hard : whether the post-forming process is applied to the material or not does not affect its properties in service. Heating takes fifty to seventy seconds in infra-red heaters, those developed by De La Rue being gas-fired. The attainment of the correct temperature is indicated by a change in the appearance of the marks of a " Tempilstick " crayon on the sheet. The sheet is then transferred to a bending jig, asbestos gloves being worn if the heated area must be grasped, and bent without delay. The sheet remains in the jig for about ten minutes to cool. " Formica " has been exploited as a body-building material on a Seddon/Carrimore articulated vehicle built as a demonstration unit for fabrication processes in small-scale production. The body of the low-loading trailer is framed in wood and sheathed in 4mm resin-bonded plywood veneered with " Formica." Grate doors on the near side open to expose the demonstration area. Woodworking machinery and cinematograph equipment are installed and there is a petrol-engined generator in the forepart of the trailer. Body sides, bulkheads and doors are faced with " Formica."

Manufacturing Fluorescent Tubes

WE have recently visited the Enfield factory of Thorn Electrical Industries, Ltd., to see the production of 8ft fluorescent tubes. A very high proportion of the work incorporated in the finished product is done by the titular manufacturers, since they build many of the machines employed and make certain of the chemicals from which phosphors are formed. The principal exception to this is the actual tube, which is of Chance glass.

The processing of fluorescent materials is principally a matter of baking at high temperatures, and the chemicals are treated in silica crucibles at temperatures up to 1300 deg. Cent. in gas-fired ovens. The mass of fluorescent material is removed from the crucible and examined under ultra-violet light, which renders any impurities on the surface readily visible. When foreign matter has been removed, the phosphor is broken up and milled to fine powder. The powder is dispersed in an organic carrier, and a dye added to allow dispersions of different phosphors to be easily identified : this colour disappears when the deposited powder is baked on the tube.

The tubes, on receipt, are cleaned by washing in purified and filtered water in stainless steel apparatus, and then dried. They are coated with fluorescent material by running the suspension down the inner walls of the tube, excess passing out of the bottom end : this is considered to be a quicker process than welling up suspended phosphor from the bottom of the tube. The tubes are dried and baked and the coating inspected visually for uniformity.

The ends of the tubes are closed by glass caps which carry the electric leads and the cathodes. A single automatic machine, shown in Fig. 1, assembles these fittings from glass blanks and prepared composite leads ; it has sixty stations and performs fourteen operations. The leads are sealed into the glass stem after it has been heated by gas burners and a hole for the subsequent mercury charging and evacuation is blown. The leads are bent to shape to carry the coiled-coil filament, which is laid in place and clamped to the nickel ends of the leads. The supply of these filaments one by one is one of the most difficult operations, as the filaments are prone to tangle together when in bulk : a supervisory attachment sounds an alarm if any space on the track visible, in the illustration, is not occupied. The machines in this works, both made by Sylvania, are believed to be the only examples in Europe of automatic stem assembly.

The end fittings are sealed on to the tube in a small rotary machine, again gas-heated : sealing is done at the bottom of the tube and hence the tubes have to be inverted by hand.

The finishing unit consists of a group of machines, the first of which commences by evacuating the tube in stages, dosing with mercury, sealing and breaking off the glass stem. The leads are threaded by hand into the metal cap and the cap stuck on : the adhesive is melted in the process, so the tubes are again inverted between the two capping processes. The contacts on the caps are then dipped, by hand, in a bath of solder, to complete the tube. The lamps then pass into the ager, which carries 134 tubes, the running time being eight minutes. Each tube is flashed up once only, and any that do not light satisfactorily are automatically rejected. At the end of the finishing unit they are checked for overall length, visually inspected and inserted into wrappings.

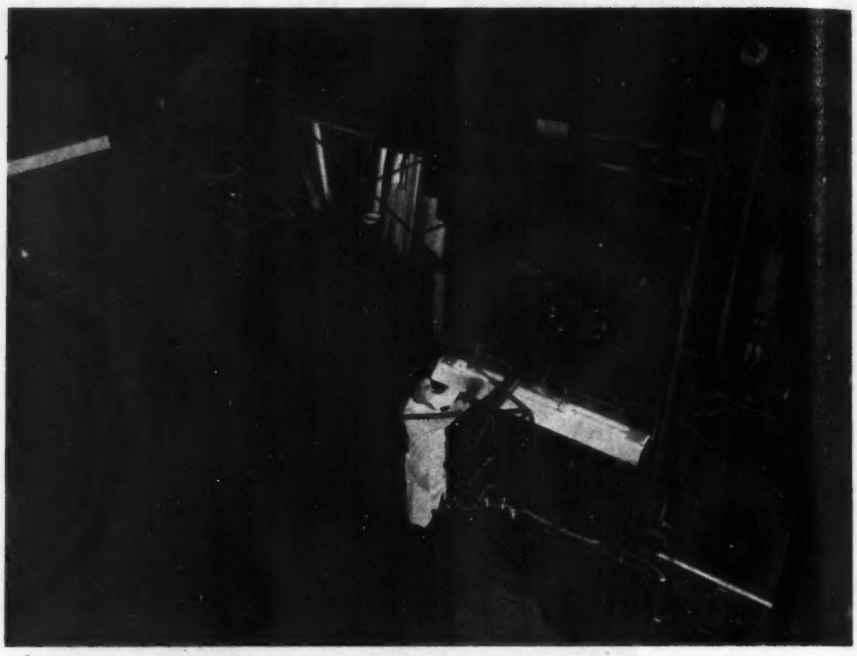


Fig. 2—The polar diagram of a light fitting is plotted automatically by this photometer

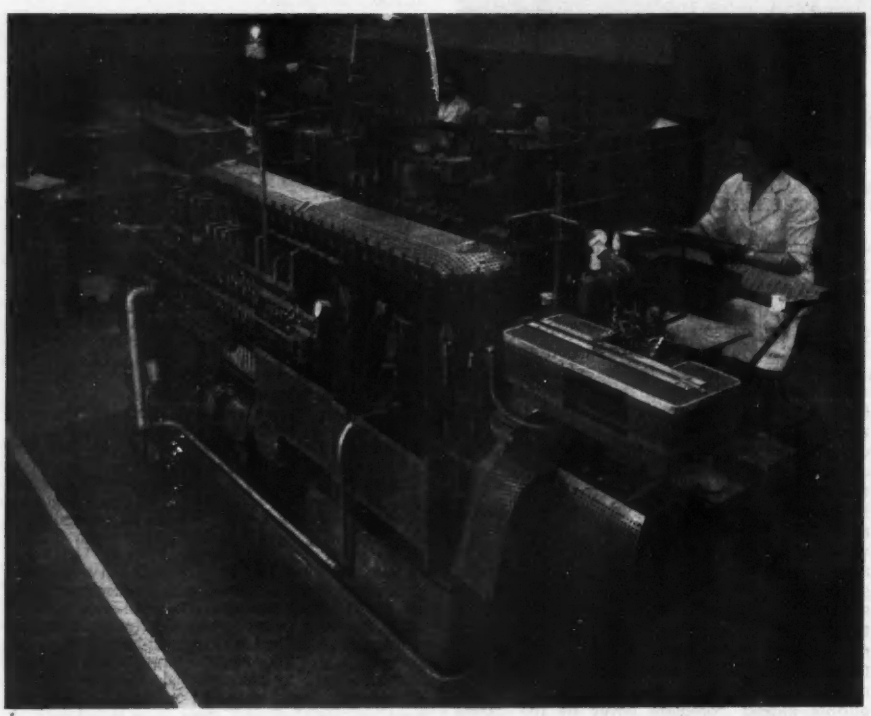


Fig. 1—This machine seals the leads into the glass stem assemblies closing the ends of the fluorescent tube. The unit in the foreground supplies coiled-coil filaments to be attached to the supporting wires

The Enfield works also houses the lighting laboratories, one of the major occupations of which is life testing. Routine life testing of fluorescent units dissipates as much as 70kW, the lamps spending three hours on and three off : tests are not usually carried beyond 6000 hours' running, since the guaranteed average life is 5000 hours. An apparatus to estimate the proportion of life remaining to a tube by comparing the thermal inertia of the cathode with that of a new unit is also used : the amount of emitter remaining in the coil determines the useful life remaining. In Fig. 2 we illustrate a photometer used to plot the polar diagram of various light fittings : to obtain realistic results the measuring unit must be about 25ft from the source, and this is achieved by carrying a mirror round the light on a long arm and reflecting the light on to a photo-electric cell seen on top of the arm near its pivot.

An intriguing demonstration in these laboratories was of electro-luminescence, whereby a treated sheet of glass is caused to fluoresce between two conducting films. Masking the plate allows a signal to be rendered visible electrically : this is found a particularly suitable way of displaying notices in aircraft, since the sign is light in weight and does not run hot.

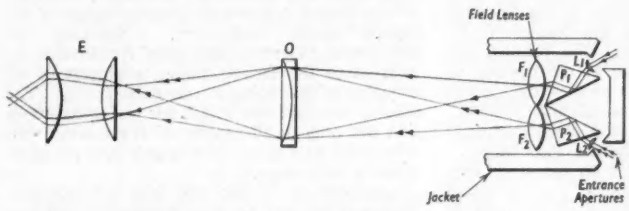
Tubes recently introduced include reflector tubes, which emit the greater part of their light through 120 deg. of their circumference. This is valuable where the bulk of external reflectors cannot be accommodated; however, the makers emphasise that the greatly increased brightness of the light sector of the tube should not face anyone's eyes. The "Domino" lighting unit, to hold one or two 2ft, 4ft or 5ft tubes, can be assembled in diverse arrangements to suit various styles of architecture, while in contrast a kitchen light with a single 4ft tube and starter-ballast lamp has been produced for domestic use.

Periscopic Television Equipment for Furnaces

A new design of water-cooled periscopic television equipment for observing furnace operation has been installed at Barking "C" power station. With it the burner wall and all the burners can be observed simultaneously through a single 4in diameter aperture and can be televised to any part of the station. It is designed for pressurised furnace operation up to 20in water gauge and can be withdrawn or left in position continuously, the camera tube being rendered quiescent until a picture is required. A portable water-cooled periscopic equipment, without television, is available for direct viewing.

LAST Friday, we visited Barking "C" power station to inspect a new form of water-cooled periscopic television equipment designed for furnace observation. The equipment was developed by Babcock and Wilcox, Ltd., in conjunction with the British Iron and Steel Research Association, Marconi's Wireless Telegraph Company, Ltd., and the Foster Instrument Company, Ltd. It makes use of a new optical system, whereby the whole of the burner wall and all burners can be observed simultaneously from a single position and televised to any part of the station. A circular aperture of only 4in diameter is needed in the furnace wall, and the equipment has been developed to suit pressurised furnace operation, so that it can be inserted or withdrawn safely against furnace pressures of up to 20in water gauge. It can be withdrawn or left in position, as required, and is equipped for automatic or semi-automatic "turn-down" operation, the camera tube being quiescent until a picture is required. Simple water-cooled periscope units, without television, can be supplied for direct viewing; they are portable.

The optical equipment, as illustrated, consists of a periscope, which is completely water cooled, with incorporated air blast to keep fly ash from settling on the lens windows. As illustrated here it is mounted, together with its associated television camera, on a carriage which can be advanced into the furnace or retracted by means of a "Martonair" remote-controlled air cylinder. If applied to a pressure-operated furnace the nose of the periscope water jacket is fitted with a conical fairing to avoid interference with the flow of air in the air blast door through which the unit enters. This door takes the form of a circular opening with gastight flaps, which are pushed open by the nose of the periscope as it advances. At the same time, high-pressure air is automatically admitted to a ring of nozzles which converge on the opening surrounding the doors. The velocity of these air jets is sufficient to induce air into the furnace and form a "curtain" which prevents any tendency towards the emission of gas or flame.



General principles of optical system of periscope for televising furnace burners

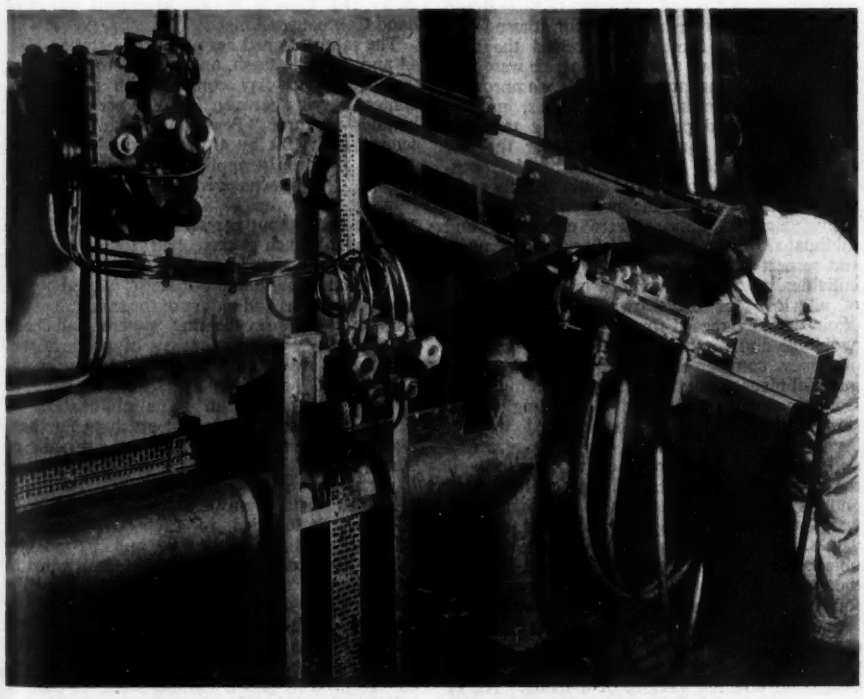
As already indicated, the fundamental requirements of the optical system were a wide angle of vision without exposed lens surfaces. A periscope for furnace observation which answers some of these requirements was used some years ago (1949) by the British Coal Utilisation Research Association. Working from this, Mr. C Burns*, of the British Iron and Steel Research Association, developed a panoramic periscope having an optical system, the rudiments of which are shown in the accompanying diagram. While the main objective lens is of conventional design, it can be located some distance away from the furnace end of the periscope. The actual observation is carried out by the use of twin entrance apertures with lenses and prisms so arranged that the two fields of view are combined in panoramic form with a dividing line at the centre of the picture.

The two apertures are near one end of the cylindrical periscope tube. If the system were viewed end on from inside the furnace the apertures would occupy approximately the "5 o'clock" and "7 o'clock" positions, giving a view of the furnace wall downwards below the point where the periscope is installed. A field of 90 deg. in one plane and 45 deg. in the plane at right angles to it can be easily resolved. The corresponding "picture" has a width-to-height ratio of 2 : 1 and the horizontal row of burners appear across the width of the screen.

A brass tube which can be withdrawn from the outer water-jacketed tube contains the optical equipment and the two apertures are covered by heat-absorbing filters. The space between the tubes is swept by air blast to prevent fly-ash from settling on the windows.

The installation includes interlocks to give protection against failure of cooling water or blast air and to ensure that both are available before the unit is advanced into the furnace. In addition, "economy" controls have been fitted since there is no need for continuous observations of a normal furnace operating under stable conditions; maximum visibility is required only during lighting up and in emergencies. The boiler control panel is fitted with a "turn-down" control so that the pick-up tube normally operates at considerably less than maximum brightness. When the furnace operating conditions are stable the periscopic unit is withdrawn and the furnace is monitored by a photo-electric cell: a decrease in the overall brightness of the furnace causes the photo-electric cell to operate an alarm on the control panel; at the same time the periscope nose is automatically advanced into the furnace and the "picture"

* "A Furnace-Scanning Periscope," *Journal Iron and Steel Inst.*, 180, July, 1955, 3, 241. "A Wide-Field High-Temperature Periscope," *Trans. Society of Instrument Technology*, 7, December, 1955, 4, 137.



Periscope ready to enter the furnace. In operation the whole of the burner wall and all burners can be observed simultaneously from one position and televised to any part of the station

Furnace periscope equipment in service, with its associated portable cooling unit comprising water tank, pump and blower

shows the extinguished burner. The operator would answer the audible alarm and, at the same time, immediately turn the camera output up to the maximum. The photocell could, of course, be arranged to do this automatically, but since the object of the alarm is to ensure that the operator immediately goes to the monitor screen to observe conditions, this additional refinement is omitted.

To enable this design of periscope to be used for direct viewing without a television link, a portable unit is now being marketed by the Foster Instrument Company, Ltd., under the trade name "Babcock-Foster Furnace Periscope." This equipment, as illustrated here, consists of the periscope unit, without a television system, and in this case it will be noted that the unit is suitable for either straight-line or right-angle viewing.

The cooling unit, which can (without water) be carried by one man, consists of a 5-gallon water tank, together with a small electrically operated circulating pump and an electric blower mounted as a unit with skids and carrying handles. The amount of water carried by this means will, it is stated, allow up to twenty minutes' observation after which the water must be changed or allowed to cool for the next period of observation.

Centenary of V.D.I.

FROM May 12th to 15th, the centenary celebrations of the Verein Deutscher Ingenieure (V.D.I.) took place in Berlin. On Saturday, May 12th, a commemorative meeting was held in the Hall of Honour at the Funkturn. A copy of the memorial erected to the founders in 1931 was unveiled by the former V.D.I. director, Herr Erich Kothe, who recalled the events twenty-five years ago at the meeting in Alexisbad. In reply, the chairman of the student members of the academic association "Hütte," H. Bahrmann, mentioned the close historical and personal ties between the two associations.

At the centenary meetings on the same day, Professor R. Vieweg (Brunswick) spoke about "Natural Science and Technology." He referred to the interactions of both these fields of human endeavour and the differences of opinion as to their relative importance. The "evils of technology" were already being attacked in the fifteenth century—when German ore-mining was the subject of complaint—but that point of view should not be over-emphasised. There was also in the opinion of some, an antithesis between the *homo ludens* of science and the *homo faber* of technology. The connection between the two aspects could perhaps best be illustrated by reference to research, especially the connection between pure and applied technical research and the related subject of invention. The last 100 years had been characterised by the growth of energetics. More recently entirely new fields of technology had been opened up by the interaction of technology with certain branches of science. By way of example, the speaker mentioned geotechnology, the beginning of biotechnology, atomic physics, electronics, and statistics. A bond between nations was constituted by modern metrology and the development of international standards. The world view of physics, based on freedom of thought and the realisation of the bounds of human knowledge was paralleled by the engineer's creative work with its feeling of responsibility.

Professor Dr. W. Finkelnburg (Erlangen) spoke next about "Technological Trends." There were two main trends, in that technology was becoming more and more "theoretical" and "scientific." By that he meant that not only was the theoretical basis in any field being utilised to an increasingly subtle degree, but technology was expanding more and more into the domains of science, and the time span between a scientific discovery and its technical application had during the last two decades been shortened to an extent which previously was not thought possible. A consequence of this had been the increasing specialisation of engineers with the result that projects of any magnitude could now be mastered only by teams of scientists and engineers of many branches. The number of creative engineers was not increasing in proportion to the growing tasks which lay ahead, and it was essential to aid their efforts by those of specially trained assistants and by technical means such as calculating machines.

Modern technology was offering mankind a dignified and secure existence. Its misuse was not the fault of the engineer but the result of the fact that moral and political developments had not kept up with the growth of technology. Close collaboration between natural scientists and engineers on the one hand and humanists and social scientists on the other was necessary in order to enlarge mutual understanding beyond political divisions.

The Centenary Festival Meeting on Sunday, May 13th, was opened by Dr. Herz, president of the central telecommunications office of the federal postal authorities. Speaking on behalf of the German Engineers' Association, he referred to the feeling among engineers of all branches of belonging to one great family. The speaker thanked the V.D.I. for giving its attention not only to all aspects of engineering, but also to the human problems which were raised by modern technology.

Speaking on "Man and His Technology," Professor Dr. Ing. M. Pfender (Berlin) said that while increasing the standard of living, technology also encouraged the craving for power. Yet fundamentally it had the character of a service and of a positive factor in human culture. The rise of modern technology was marked by three main developments, the large-scale generation and transformation of energy, the growth in transport and communications, and the increase in production of raw materials, together with the synthesis of many basic substances. These developments unavoidably resulted in social changes, both for the family and for the individual. Division of labour and separation in space of work and leisure, gave the individual knowledge and experience which he did not share with others, and in that way he lost the common domain of thinking and caring.

Collaboration in a collective task often lowered the consciousness of a personally completed achievement and raised a number of factual and psychological problems both for those who contributed and those who received the contributions of others, and also as a rule were in a position of dependence. To find a compromise between the interests of individuals, groups, organisations and peoples, became a task full of responsibility for each of us, for the law and for the state. The almost limitless possibilities of technology could most reliably serve the interest of all of the personal egoisms of individuals and nations were controlled and sublimated on the basis of voluntary endeavour and respect for other people. The variety and individuality of endowments would be the gain of all, love for one's own people need not diminish one's regard for others, war would be avoidable and competition could take the form of honest commerce. These possibilities on a material plane existed in principle for a humanity increasing in number and demanding higher standards. They could be realised without lasting spiritual damage and constantly recurring and ever more dangerous convulsions only if the meaning and object in life of the individual, and his thoughts and actions in the community, were oriented according to an accepted order of values. The individual must stand above material objects, the people above the political form of the state, and the administrative power better founded upon authority than upon force. Religion ranked before philosophy, and philosophy before technology; the last, however, was a single great service and as such more than ownership and the gaining of a living. All of us were responsible for technology, and in this field, as in all others in life, the problem that confronted the individual on his way to the Creator was the always constant one of proving himself in his relations with his neighbour.

In the course of the celebrations, the Grashof Commemoration Medal was presented to Dr.-Ing. Fredrik Ljungström (Fiske Bäckskil, Sweden) and Professor Dr. Ernst Schmidt (Munich). This brings to fifty-one the number of engineers and scientists to whom the award has been made since its inception in 1894. The V.D.I. medal was presented to nine people, among whom, best known to English-speaking readers, will probably be Mrs. L. Gilbreth (Montclair, N.J.). Seven young engineers received the V.D.I. ring of honour.

The Verein Deutscher Ingenieure was founded at Alexisbad (Harz) on May 12, 1856, by members of the academic association "Hütte," itself founded ten years earlier at the Royal Prussian College of Technology, Berlin. The twenty-three young founders, among them R. Peters, F. Euler and F. Grashof, showed great foresight in drawing up the V.D.I. constitution which provided for decentralisation through the forming of local groups, and the concentration of the overall administration in the hands of a director. The association grew within the first year to number seven local societies with 300 members; after ten years, these figures were fourteen (1300), after twenty-five years, twenty-six (4000). In 1931 there were fifty-three local groups and three abroad, with, together, over 30,000 members. After the second world war the V.D.I. was re-established in Western Germany in August, 1946, and it has now 32,000 members, organised in thirty-eight local associations.

The occasion of the centenary celebration has been marked by a special issue of the V.D.I.-Zeitschrift.

Electrically Heated Vibrating Screens for Sand

IN our issue of December 25, 1953, a description was given of an installation of electrically heated vibrating screens used in the preparation of clay for tile making. The heating equipment for these screens was supplied by the Woden Transformer Company, Ltd., Moxley Road, Bilston, Staffs, and the system proved particularly successful in preventing "blinding" of the screens which had hitherto necessitated frequent stoppages for cleaning purposes. Since that time the firm has installed a number of these heating equipments, and we were recently invited to inspect one of its larger installations at the Berry Hill Quarry of the Mansfield Standard Sand Company, Ltd.

The sand screened lies primarily between Nos. 44 and 120 B.S. mesh, and has a 4 to 5 per cent well-distributed clay content with a moisture content varying between 7 and 10 per cent. It is handled on three "Pegson-Telsmith" vibrating screens each 10ft by 4ft with three frames per screen. Before the application of electric screen heating, the screens were all of slotted mesh 1¼in by 5/16in by 14 S.W.G., which gave an average throughput per screen of 20 to 25 tons per hour. Each screen had to be brushed manually with wire brushes at frequent intervals to eliminate continual "blinding" caused by the moist conditions and nature of the sand.

After the screen heating system had been installed an improved quality of product was attained by reduction in mesh size to ¼in by ¼in by 14 S.W.G., and there was a 30 to 40 per cent increase in throughput. The elimination of "blinding" and its attendant brushing for these rates of screening resulted in an overspill of "true rejects" only, varying between 2½ and 7½ per cent.

In this installation a transformer rated at 31·5kVA is applied to each screen, under balanced loading conditions, and by passing heavy electric current through the mesh wires at low voltage, a uniform heat is obtained over the whole area of the screen. As the current rating required depends upon the size of the mesh of the screen, the temperature of the raw material and its moisture content, the tapped transformers are arranged to give a suitable range of current ratings. It is stated that with each screen running at 30 tons per hour throughput, the electrical consumption is about 0·5 units per ton per hour.

Industrial and Labour Notes

Industrial Accidents

Last week there was published a report by the industrial safety sub-committee of the National Joint Advisory Council, which urges that " the prevention of accidents is a task which industry must accept unreservedly." The sub-committee was appointed to review the position of safety in factories and other places of industrial employment subject to the Factories Acts, and to make recommendations on ways and means of securing greater freedom from accidents. The report says that the time lost to industry on account of incapacity of insured workers through industrial injuries is a little short of 20,000,000 man-days a year. Every day some 60,000 workers are absent as a result of industrial injury. Accidents reported under the Factories Acts alone account for 700 men and women killed each year and 180,000 injured. About three in every 100 men and boys in factories, and one in every 100 women and girls are injured in accidents and are away from work for at least three days. The accident rate, the report points out, has changed little in recent years. Only one in every six reported accidents is caused by power-driven machinery ; most accidents arise from everyday causes such as falls and handling goods.

The main conclusions reached by the sub-committee are that accidents can be prevented by positive action, and when they happen are a reflection on efficiency ; safety must be a definite aim throughout industry ; legislation must be kept abreast of industrial developments and must be observed and enforced ; there is need for more vigorous, more extensive, more sustained, and better organised efforts to prevent accidents in industry on the part of managers, supervisors and workers and also technicians, planners, designers and research workers. The report emphasises the need for the organisation of safety in a works, by which is envisaged " everyone in the works making sustained co-operative efforts to secure freedom from accidents." On this point, the recommendations made by the sub-committee are that safety must be accepted as a policy from the top to the bottom of the undertaking ; that arrangements should be made to identify and study hazards and risks of accidents in the works, and that action should be taken to eliminate the potential causes of accidents and safeguard workers from the risks which remain.

The report goes on to discuss the contributions to accident prevention which can be made by management and workers, singly and jointly. It comments on safety training arrangements and upon the part which can be effectively played by employers' and workers' organisations. Moreover, it is urged that more attention should be paid to research into safety matters. The sub-committee considers that, to ensure effective use being made of available resources, there should be some focal point where the need for and the progress in industrial safety research can be analysed and kept under review, and from which action can be initiated and co-ordinated. To that end, it recommends the establishment of a standing national committee, representative of Government and industry. The function of such a committee, the report says, should be to keep under constant review progress in furthering all aspects of industrial safety and in particular to consider requirements in the field of research.

Factory Fire Alarms

Before the House of Commons adjourned for the Whitsun recess last Friday, the matter of fire alarms in factories was debated. The debate was initiated by Mr. C. R. Hobson, who spoke in particular about the circumstances of a serious fire in a woollen mill at Keighley last February.

When the Parliamentary Secretary to the Ministry of Labour, Mr. Robert Carr, replied to points raised in the debate, he announced measures which it was intended to effect in order to improve factory fire precautions generally. He emphasised that a requirement of the Factories Act, 1937, was that a fire alarm must be installed in any factory where there were more than twenty workers or where explosives and highly inflammable materials were stored or used. There was no doubt, Mr. Carr said, that non-compliance with that essential provision was widespread and serious ; it was estimated that no less than between 50 and 70 per cent of the factories covered by the requirement did not have fire alarms. Mr. Carr went on to say that the Chief Inspector of Factories was writing to all factory occupiers covered by the provision to remind them of their obligation to install fire alarms. There were from 40,000 to 50,000 premises involved, and the problem was how to follow that up without disturbing the normal work of the factory inspectors. The Minister of Labour had, therefore, decided that officers from employment exchanges would assist the district inspectors in carrying out a rapid survey by personal visits to all the factories concerned throughout the country.

Mr. Carr added that there were technical difficulties in fixing effective systems of fire alarms. The Ministry thought that there was need for some simple guidance on the matter, so, as well as the personal approach, a leaflet was being prepared giving advice on the installation of fire alarms and pointing out some of the difficulties to be avoided.

Volume of Exports

The Board of Trade has stated that the volume index of United Kingdom exports (1954=100) was 111·8 in the first quarter of this year. The figure for the comparable period of 1955 was 111·2, but that figure, it is suggested, was inflated by goods which were delayed by the dock strike in the latter part of 1954. Allowing for this, the Board of Trade says, the increase in volume of exports between the first quarter of last year and this year was probably about 5 per cent, which was approximately the same as the underlying rate of increase in volume which prevailed throughout 1954 and 1955.

Government Scientific Staffs

The Institution of Professional Civil Servants held its annual delegate conference in London last week. At the opening of the conference, the chairman, Mr. J. F. Fry, said that for some time the Institution had been devoting a major part of its energies to matters arising from the report of the Royal Commission on the Civil Service. That had been both " natural and essential."

But, Mr. Fry continued, there were other matters to which he thought some attention might be devoted, and one such was the question of technical education. That was obviously of close concern to many members of the Institution because of the requirements of their jobs, quite apart from its general social importance. For some years, Mr. Fry said, there had been a growing concern about the shortage of scientists and technologists. In view of this, the recent White Paper on Technical Education was expected to contain some pretty clear-cut plans for increasing the number of students taking higher technical courses. In this respect, Mr. Fry commented, it was a most disappointing document, for a large part of it was little more than a catalogue of hopeful suggestions.

Mr. Fry went on to say that, in the White Paper, the difficulties of obtaining more full-time teachers were virtually brushed aside, and little attention appeared to have been given to the fact that there was already some difficulty in filling existing vacancies for students, so that the possibility of filling a large number of newly-created ones was somewhat remote. The necessity to create a suitable climate of opinion so that young people were encouraged to take up science or technology, Mr. Fry commented, was almost completely ignored. That, he added, was one of the major points in the Institution's evidence to the Royal Commission. The Institution had suggested that the Government should shoulder its responsibility by setting a lead to industry in the salaries offered to its scientific staffs. That, Mr. Fry asserted, was undoubtedly a very important factor. Furthermore, he said, if, as it appeared, the Government was going to rely on the co-operation of employers, it could not escape its own responsibilities as an employer. It must expect to have to set an example by allowing its own staff time to attend sandwich courses and by granting facilities to those who were able and willing to undertake part-time teaching.

National Industrial Fuel Efficiency Service

Some " second thoughts " on the National Industrial Fuel Efficiency Service were voiced by Dr. Angus Macfarlane, its chief executive, in an address which he gave last week to the Fuel Luncheon Club. Dr. Macfarlane reviewed the work of N.I.F.E.S. since its formation two years ago, and recalled that the pattern so far developed was three-fold : an advisory service to appraise the possibilities of fuel saving ; a heat and power survey to measure accurately the improvement that could be made, and a regular follow-up system to make sure that operation and maintenance were kept on the top line.

In less than two years, Dr. Macfarlane continued, N.I.F.E.S. had made contact with one in four of the fuel consumers in this country and provided them with preliminary advice. The next logical step was the heat and power survey which showed by accurate measurement exactly where energy was used or wasted in a boiler plant, in any part of the process, or in the works as a whole. During the last year, Dr. Macfarlane said, 495 such heat and power surveys had been carried out, an increase of 51 per cent on the preceding year. That work now occupied over one-third of the total engineering time that N.I.F.E.S. had at its disposal.

The third branch of the work, Dr. Macfarlane explained, was the " regular service agreement." That branch had made the most rapid progress during the last year ; it had been devised to meet the demand for continued advice that arose once an industrialist appreciated how great were the savings of fuel to be obtained through a high standard of operation. The attractiveness of the scheme was shown by the fact that the agreements had increased from seventy-eight at the beginning of last year to 262 at the end. The total number of plants covered was much greater as many of the agreements with industrial organisations were for all the factories in the group, or with local authorities for the many buildings under their control.

Trade Unions and Automation

As recorded in these notes in our last issue, a conference of trade union representatives from the United Kingdom and several continental countries has been held in London to discuss matters concerned with automation. The conference was organised for the European Productivity Agency by the Trades Union Congress.

At the end of the conference, on Thursday of last week, Mr. James Crawford, chairman of the T.U.C. production committee, said that the conference had not aimed at the elaboration of any official trade union policy. One point, however, which had emerged from the discussions was that the novelty of automation lay less in the technical principles involved than in the speed of their application. That was a matter which raised new social and economic problems. A statement issued after the conference referred to a lack of information and statistics about the present impact of automation in Europe, which made any precise assessment of future trends difficult. But, the statement declared, in automation, as in all industrial developments at works, national and international levels, trade unionists demanded the chance to negotiate and, together with the community, they expected to share the benefits. On their part, trade unionists recognised that unions would have to give special attention to equipping themselves for their responsibilities.

German Industries Fair, Hanover

No. III—(*Concluded from page 540, May 18th*)

THE German Industries Fair was held at Hanover from April 28th to May 8th. Some of the engineering exhibits are described here.

Ernst Leitz G.m.b.H.

A comparator with an accuracy of ±1 micron (0·00004in) and a range of ±70 micron was shown by Ernst Leitz G.m.b.H., Wetzlar. The large range of this instrument, the "Tolerator," is of special usefulness in quality control work, where scatter is often considerable. Both inside and outside dimensions can be checked with the same degree of accuracy. A scale with optical pointer (the edge of an illuminated sector) is provided, which, in addition to linear divisions, and adjacent to them, carries a division into classes, consisting of groups of dark and light blocks. By rotating the scale which is on the surface of a cylinder class markings of the required block width can be selected. The use of this scale facilitates the grouping of the measurements in classes with a considerable saving in work and less possibility of error. For the recording of the class frequencies there were shown a mechanical counting unit, the "Statitest" (manufacturer, Ferrari, Berlin), and an electrical counter and tabulator, the model "M126" (manufacturer, Dr. Masing, Erbach/Odenwald). These units are shown in Fig. 12.

Fig. 12—Comparator with classification and statistical unit—Ernst Leitz, G.m.b.H., and Dr. Masing

The "M126" tabulator gives the possibility of obtaining directly the percentage frequencies, which can then immediately be plotted on cumulative frequency graph paper.

Siemens and Halske Aktiengesellschaft

A multi-point temperature indicator, which was shown by Siemens and Halske Aktiengesellschaft permits the selection in any sequence of one of 200 measuring points (thermocouples). The temperatures are indicated with an accuracy better than ±0·25 per cent of the range (which is between 5 and 500mV). Each reading takes two to eight seconds, depending on the gear ratio chosen for the indicator.

The principle of measurement is the amplification, by means of an electronic a.c. converter-amplifier, of the out-of-balance current of a Wheatstone bridge network; the amplifier output operates a null motor which, by rotating a variable resistance, feeds back a compensating voltage, and at the same time turns the cylindrical indicator scale (which is 490mm long) past the fixed pointer.

Selection of a measuring circuit is made by pressing the corresponding button on the control panel. This "dials" the circuit on an automatic telephone exchange consisting of several racks of model "EMD" noble-metal uniselector motor switches. The (Fig. 13) selector immediately reports back the position it has reached, which is shown by an electric bulb lighting up in the press button. This enables a check to be obtained that the instrument is functioning correctly. If necessary, the capacity of the selector unit can be

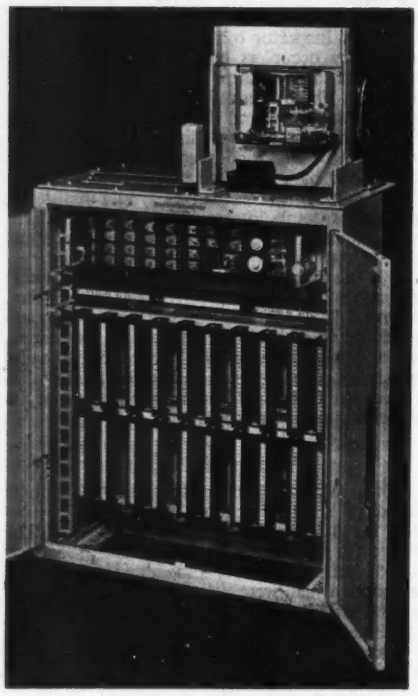


Fig. 13—Circuit selector for multipoint temperature indicator—Siemens and Halske A.G.

extended still further, and the instrument can be modified to give a signal if the temperature at the selected point varies from a previously fixed value. Automatic selection of the measuring points is possible, and the two modifications can be combined.

Calor-Emag

On the stand of Calor-Emag Elektrizitäts-Aktiengesellschaft, Ratingen, was shown the rolling contact rectifier illustrated in Fig. 14. Built for the conversion of mains a.c. power into medium-voltage d.c., the machine is stated to have a very high efficiency.

Essentially, it comprises two parallel stationary rings bridged by two metallic rollers rotating on the inner surface of the rings. For three-phase operation, each ring is made up of three equally spaced metallic segments with insulating segments in between. The three contact segments of one ring are connected to the three input phases, while the three segments of the other ring are connected to one another, thus forming one pole of the d.c. circuit. By moving the rolling contacts over the rings in synchronism with the a.c. frequency, the input current is rectified, since electricity can flow only between segments which are at that instant bridged by a roller. It is necessary to control the instant at which contact is made as well as its duration, and this is achieved by ranging the phase angle between the driving motor and the rollers and the phase angle between the two rings by respectively turning the motor stator in relation to both rings or by turning the output ring in relation to the input ring. For very large currents, several pairs of contact rollers are connected in parallel and several pairs of contact segments are used. Moreover, two similar units may be placed at each end of a single motor. Thus, the tandem unit illustrated has three pairs of rollers and nine pairs of contact segments at each end, giving it a

Fig. 14—Mechanical rotary rectifier for 2×12,000A, 800V, d.c.—Calor-Emag

capacity of 2×12,000A, the insulation being designed for a working d.c. voltage up to 800V.

Each contact roller consists of two contact rings arranged elastically on rubber and connected by a number of equally-spaced conductor bars, the mass of the assembly being kept low to achieve long life and a minimum of noise. Contact pressure is generated by centrifugal force of the rollers and controlled by means of counterbalance weights on adjustable lever arms. In this manner, uneven wear is automatically taken up and during standstill the rings are relieved from pressure. To achieve sparkless operation of the contacts, commutating reactor windings are fitted. Protective and switching devices are incorporated.

Losenhausenwerk

On its open-air stand Losenhausenwerk Düsseldorfer Maschinenbau A.G., Düsseldorf-Grafenberg, showed vibrating equipment for concrete, soils and rock, with electric, pneumatic or internal combustion engine drive.

The "Vibromax AT2000" vibrator for the consolidation of loose material is a diesel-

Fig. 15—Two single vibrators combined to form a twin unit—Losenhausenwerk

driven unit of 6 h.p. weighing about 600 kg. Its vibrating forces can be set at approximately 1000 kg, 1500 kg, and 2000 kg, with a frequency adjustable between 400 and 1200 cycles per minute. The machine consists of a base plate, 1020mm by 625mm in size, with an effective area of 0·4 square metres. This plate carries the out-of-balance mechanism, which generates the vibration. Above it, and elastically connected with it, is a top plate on which are mounted the prime mover and the control handle. The illustration Fig. 15 shows two such units coupled together. It is possible to combine several vibrators by rigidly joining the top plates. For transporting the machine it can readily be converted into a trailer. It has a working speed, either forward or backward, of 5m to 20m per minute, and an hourly capacity of 200–600

Fig. 16—20-ton capacity crane-operated vibrator—Losenhausenwerk

square metres, to a depth of 200mm to 500mm. Two levers on the control column serve to change instantaneously the direction of travel and to vary the frequency. The unit can be stopped by disengaging the motor clutch. Multiple units can be operated by one man and are steered by varying the direction of travel and its magnitude in one or more of the units. In this way the assembly can, if required, be made to turn on the spot.

Also demonstrated was a crane-operated vibrator, the "Vibromax KR 20,000," shown in Fig. 16. Its vibrating force, exerted on a base plate of 2·25 square metres, can be varied between 5 and 20 tons, and its frequency between 400 and 2000 cycles per minute. The unit, which weighs 7500 kg, is normally slewed by the jib of a mobile crane. With a rated power of 75 h.p. it can deal with up to 200 square metres per hour, being effective to a depth of 1m to 2m. For operation on slopes, angle plates up to 45 deg. can be bolted to the base and the mechanism set for the vibration to be directed at right angles to the slope.

Maschinenfabrik Augsburg-Nurnberg A.G.

As a new development, the Maschinenfabrik Augsburg-Nürnberg (M.A.N.), Nürnberg, showed an 18-ton auto crane which is illustrated in Fig. 17. It can lift 18 tons at 4·6m radius, 10 tons at 3·12m, while turning on the road wheels, or 8·5 tons with the superstructure slewing through 360 deg. The jib for maximum lift is 10m long; for excavating, a 13·5m jib with a 0·5 cubic metre grab can be fitted. Two engines of 100 h.p. are installed for locomotion and crane work respectively. A speed of 50km per hour can be reached on the road, gradients up to 42 per cent and lateral slopes of 36 deg. can be negotiated, and the four-wheel steering permits a minimum radius (measured to the outer

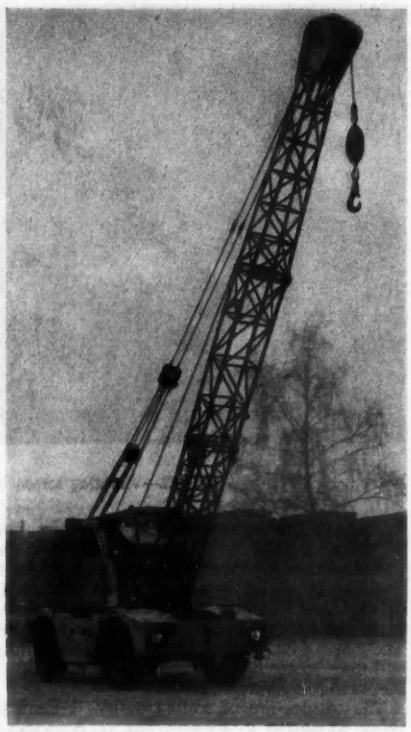


Fig. 17—18-ton capacity crane—Maschinenfabrik Augsburg-Nurnberg

front wheel) of 3·95m. All controls are pneumatic-hydraulic from the driver's cabin, and all speeds are infinitely variable. The crane has four-wheel drive, with independent suspension and differential lock. This, together with its good ground clearance, renders it very manœuvrable off the road.

The testing machines department of M.A.N. exhibited a 40-ton universal testing machine of recent design, which is stated to be sufficiently accurate to be used in research and also of such robust construction that it can be safely employed in an industrial works. The item which was shown is one of a series of machines of 10, 20, 40, 60 and 100 tons capacity, and has an easily manipulated clamping device which can readily be kept clean. The control unit has a large diameter scale and direct and fine pressure adjustment, together with electrical indication of the range, and equipment for sinusoidal load fluctuations at up to 100 per minute.

For the static and dynamic testing of large structural components and sub-assemblies, use is made of combinations of single hydraulic cylinders, in conjunction with test rigs designed specially for the requirements of each case. Our illustration (Fig. 18) shows such an installation for the testing of reinforced concrete slabs at up to 200 tons. The company exhibited its series of testing cylinders which range from 10 to 100 tons capacity, together with models of complete set-ups. Another item shown was the model of a 750-ton testing machine for wire ropes.

Robert Bosch G.m.b.H.

Among the electric tools shown by Robert Bosch G.m.b.H., Stuttgart, was the newly-introduced electric screwdriver and spanner for tightening screws and nuts from 2mm to 3·5mm diameter. Weighing only 400 grammes, the tool is operated by high-frequency three-phase current of 42V.

Also shown was a single-piston grease pump which, in conjunction with grease distributors, serves to give accurate dosage at each greasing point in a multi-point installation. The pump is operated either by a hand lever or by a compressed air cylinder actuated by push-button or some mechanical detent. If compressed air is used, the air line is automatically unloaded on completion of the greasing operation, which may be indicated by a warning light.

For central lubrication, especially of machine tools, a fully automatic installation has been developed in which several circuits can be supplied at regular intervals and independently from each other, with the correct quantities of oil.

Kloeckner-Humboldt-Deutz A.G.

In the outdoor area of the fair, the Humboldt works, Köln-Kalk, of Kloeckner-Humboldt-Deutz A.G., exhibited a number of mineral dressing machines, including a 20ft high coarse reduction gyratory crusher, the "Model 176," which is capable of dealing with material up to 32½in by 43½in. Of particular interest here is the design of the crushing chamber (Fig. 19), in which the symmetrically convex form of the lower crushing ring, located in the zone of maximum stress, is stated to lessen the power consumption, increase capacity and lead to a favourable utilisation of the valuable manganese steel. The design is "non-choking," so that products of cubical shape are obtained without an undue proportion of the undesirable fines. The sectionalised lining of the crusher shell consists of staves which are tightly held in annular arrangement by means of self-tightening steel wedges. This gives maximum rigidity, reduces the assembly time and facilitates maintenance. The self-adjusting bearing shells of the eccentric sleeve automatically compensate for any end pressures due to inaccuracies in the assembling. By virtue of a hydraulic coupling in the drive, the crusher can normally be started with the chamber filled with material. Operation is controlled by the Humboldt "Electromat" automatic unit and this, together with the lubricating and oil-conditioning equipment in-

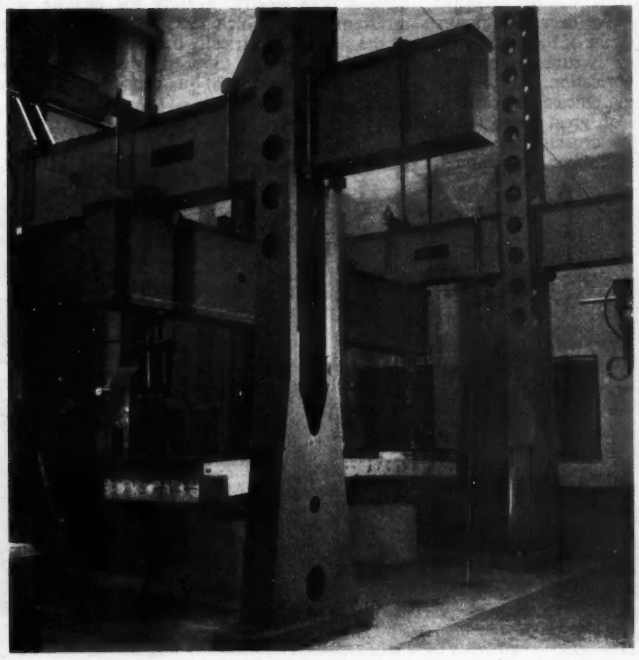


Fig. 18—Testing installation for concrete slabs, of 200-ton capacity, equipped with hydraulic power cylinders—Maschinenfabrik Augsburg-Nurnberg

corporated, serves to protect the machine against possible mistakes of the operator or negligence during maintenance. Should unbreakable materials be fed into the crusher, the breaker cone stops moving and the hydraulic coupling operates at its maximum moment. The motor is then automatically switched off by a limiting torque device in the control unit. Owing to the use of a hydraulic coupling, a squirrel-cage motor with direct on-line starting can be employed. The upper diameter of the receiving opening of the "Model 176" is 98·5in, power consumption 80–130 h.p., and the hourly capacity at 5in setting approximately 300 cubic yards. Like the smaller sizes of this design, the unit can be mounted on triple caterpillar tracks.

Descending from a long line of development—the first jaw crusher in Europe was built by Humboldt in 1857—the "Model 267" low-frame jaw crusher, illustrated in Fig. 20, is a

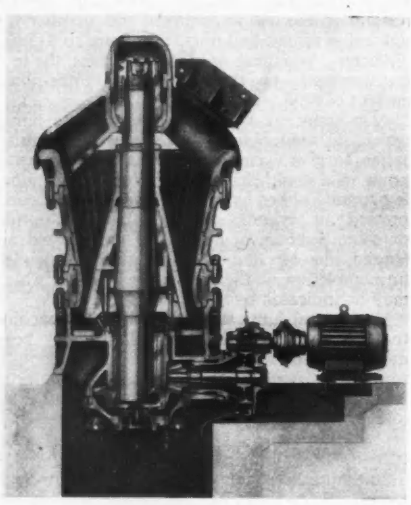


Fig. 19—Section through primary gyratory crusher—Kloeckner-Humboldt-Deutz

recent "non-choking" design marked by its versatility, being one of twenty-eight designs of this type. Built to handle material up to extreme hardness, it is of composite rolled-steel and cast steel construction, combining rigidity with low weight. The curved shape of the lower part of the fixed jaw plate is stated to ensure a well-calibrated crushed product without excessive fines, and in addition to give decreased power consumption and reduced wear of the manganese steel parts. The swing jaw is rubber-supported and does not need any lubrication. In view of the difficulty of maintaining efficient lubrication of this member, this is of great importance. Shocks resulting from the crushing operation are well absorbed by the rubber and enough freedom of movement is left to reduce end pressures in the toggles, thus relieving the eccentric shaft of excessive strain and render it possible to equip this shaft with accurately dimensioned bearings. The machine is stated to be the first to employ anti-friction bearings. These are of heavy design as used in rolling mills and may be readily exchanged with the help of oil-pressure-operated devices.

The toggles are of rolling design, instead of being supported in sockets, and so consume a minimum of power and require little lubrication. Broad shims serve to avoid twisting the pitman when resetting the discharge gap. Driven by a squirrel-cage motor of 125kW, the machine takes material up to 45in by 37½in and has an hourly throughput at 6·3in setting of the discharge gap of 210–235 cubic yards. Its receiving opening measures 49·2in by 39·4in. Automatic protection against overload is obtained by including a hydraulic coupling in the drive, together with prestressed friction clutches in the flywheel hubs on the eccentric shaft. The latter allow the jaw to stop immediately under excess force while the flywheels come to a standstill under friction.

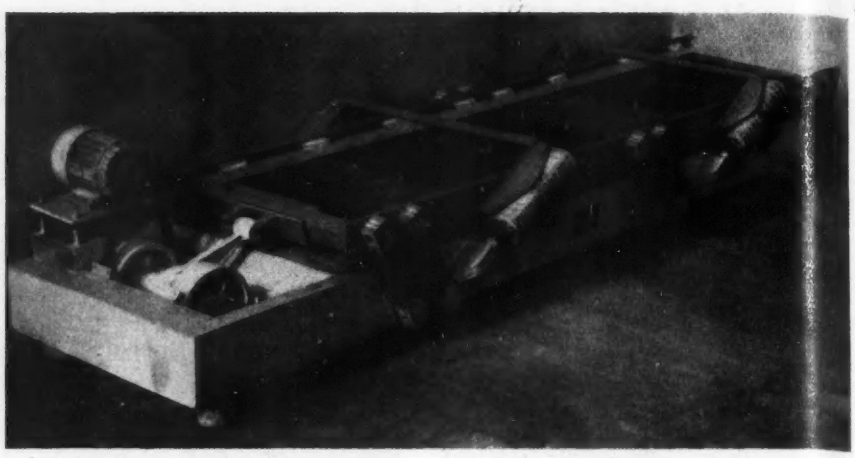


Fig. 22—Vibrating screen for low headroom—W. Flämrich

W. Flämrich

The firm of W. Flämrich, Recklinghausen, showed examples from its production of vibrators, vibratory conveyors and screens, including screens with electric heating for dealing with moist materials which tend to clog the meshes of the sieves. Electrically heated screens operate on 40V to 60V a.c., supplied by single or three-phase transformers of a capacity of about 10kVA per square metre. For mesh sizes of 3–4mm, the consumption of heating energy per ton is of the order of 1·2kWh to 1·8kWh. For three-phase installations which become necessary for the larger sizes in view of the phase unbalance which would otherwise occur, the transformer primary has three-phase windings, while the secondary can be either single-phase, two-phase or three-phase in star connection. The screen is insulated from the supporting frame and is subdivided into suitable strips where necessary. Flexible leads are used to supply the current.

A special recent construction requiring low headroom was shown which has a maximum height, taken over the centre, of 900mm. The screen measures 5000×1200mm. With an installed power of 5kW, throughput of coke or gravel is up to 100 cubic metres per hour. The machine is illustrated in Fig. 22.

Daimler-Benz Aktiengesellschaft

The Daimler-Benz Aktiengesellschaft, of Stuttgart-Untertürkheim, introduced this year the model "MB837" diesel engine (Fig. 21). It is an eight-cylinder engine with vee arrangement. Equipped with supercharger, its output is 650 h.p., 2200 r.p.m., for a weight of about 1400 kg, or 2·33 kg per horsepower. It has dry-sump lubrication, so that it can be operated with an inclination of 40 deg. in any direction. The bore is 165mm, the stroke 175mm, and the total stroke volume about 29·9 litres. The machine is complete with electric starter, dynamo and safety device for protection against overheating and failure of the lubricating oil pressure.

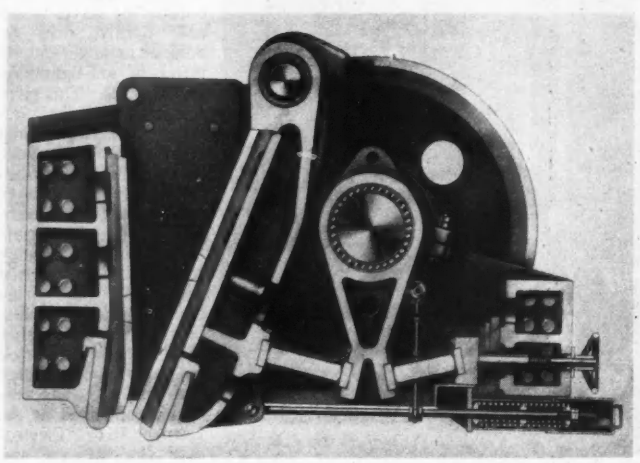


Fig. 20—Section through low-frame crusher—Kloeckner-Humboldt-Deutz

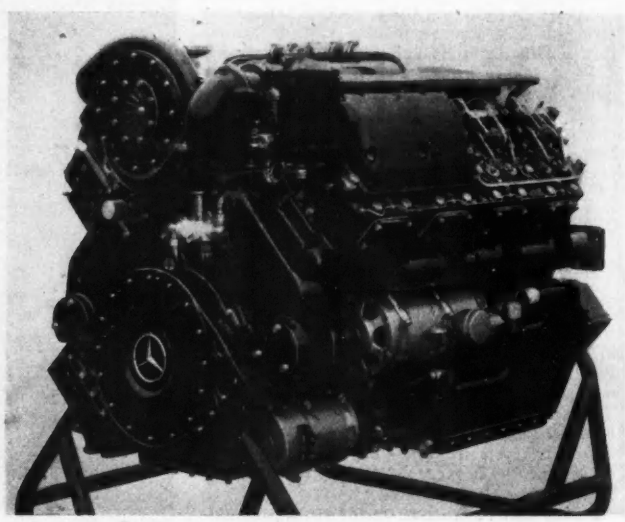


Fig. 21—Model "MB837" eight-cylinder, 650 h.p. supercharged diesel engine—Daimler-Benz

The American Scene

BY OUR AMERICAN EDITOR

THE WESTINGHOUSE STRIKE

VICTORY is a compelling word, which, as the poets and politicians discovered centuries ago, has the power to stir the blood and make the pulse race faster. "Westminster Abbey or victory!" Lord Nelson is said to have cried at the height of a bitter sea engagement and on many another martial occasion, similar sentiments have been flaunted as proudly as any banner. At the same time, however, there exists a certain minority view on the subject; while less strident perhaps, it seems equally worthy of respect. In the final analysis, many a victory found in history would hardly seem worth the sacrifice it required and the suffering it brought upon the so-called victor. Such thoughts may well apply to the recent settlement of the long strike at the Westinghouse Electric Corporation, easily the worst labour dispute to have occurred in the American engineering industry since the last war. In making the welcome announcement of the settlement, James B. Carey, the head of the International Union of Electrical Workers, termed it a "clear-cut victory" for organised labour. "In Westinghouse," he added, "the I.U.E. has provided a lesson in militancy and fraternity for the world to remember." Mr. Carey, of course, is entitled to his views. On the other hand, some student of labour relations, possibly even in his own camp, might well raise an eyebrow at such vainglory. While the union undoubtedly made some handsome financial gains, these, by and large, could have been won without a walk-out which cost its members many millions of dollars. Equally significant, the protracted dispute has made it plain that in the house of labour dwell men who are willing to put their own cause above that of the rank and file, to say nothing of the public at large.

The facts of the Westinghouse strike are quickly set forth. Settled after 156 days which were marked by bitterness at the bargaining table and violence on the picket line, the dispute cost the workers more than 70 million dollars in wages and the company some 250 million dollars in sales. It also exacted a large if undisclosed sum from the U.S. Treasury in lost taxes. Ironically, the principal quarrel between the two parties did not involve such basic dollars-and-cents considerations as pay scales or "fringe" benefits. Instead, the dispute centred around two issues of a different nature: length of contract and management prerogatives. Westinghouse wanted, and in the end got, a five-year pact with the I.U.E. similar to that concluded earlier by its chief competitor, General Electric. The company also demanded the untrammelled right to set standards of efficiency for its work force, including both production and service employees, a point on which it ultimately gave some ground. True, toward the end, tempers flared over how to treat workers discharged for lawlessness. But in the ordinary give-and-take of negotiation it should have been possible to iron out such differences at far less cost in blood and treasure. What happened, of course, was that there was no give-and-take. Instead, the bargaining was carried on in an unyielding atmosphere of rancour and recrimination, made more poisonous by a series of labour disputes which had erupted earlier. To this unpleasant climate both sides undoubtedly contributed. However, while it may have made matters worse, something more deep-seated than malice was involved at Westinghouse. For the strike, it appears from the record, was precipitated and prolonged to carry out the doctrines and advance the interests not of the average electrical worker, but of a few union leaders. Support for this view may be found in the circumstances which led up to the record-breaking walk-out. A few weeks before it began, local branches of the I.U.E. and the General Electric Company, with scant help from Mr. Carey, hammered out a contract which seemed to please all hands. Effective for five years, a provision inserted at the company's behest, this document also provided a generous package of hourly pay increases and other benefits. To Mr. Carey and his followers at I.U.E. headquarters, however, what was good for General Electric obviously could not be good for them. In any case, the International Union of Electrical Workers, rejecting the pattern set at General Electric, sought more from Westinghouse while offering considerably less. The latter, which, after all, must compete in the same markets, could do nothing but accept the strike which inevitably followed. To some extent, then, the trouble at Westinghouse was caused by men whose reach exceeded their grasp, financial and otherwise. But this is not the whole story. For it appears that their stubborn refusal to come to terms, in part at least, was based also on doctrinaire opposition to signing a long-term contract. Admittedly this is a controversial idea. Since 1950, when it was unveiled in the American motor-car industry, labour and management experts alike have lined up on both sides of the fence. The bulk of the evidence now suggests that such agreements, by guaranteeing a period of industrial peace, also serve as a spur to long-range corporate planning and, thereby, to continued prosperity. Such labour leaders as Walter Reuther and those of like persuasion, may disagree with this thesis, and their reasoning undeniably has some weight. But it is one thing to propound an economic argument, it is quite another to wage unlimited warfare on its behalf.

Now the strike has come to an end and an uneasy peace has been restored. The wounds it has inflicted, material and spiritual, will be long in healing. Yet there may be a grain or two of comfort to be drawn from the whole disastrous affair. For those who are not too blind to see, the Westinghouse strike has dramatised some important truths about organised labour in the United States. It has shown the incredible power which a few men, for good or ill, can wield over thousands of their fellows. It suggests unmistakably that such power, unless curbed, may be subject to great abuse. Sooner or later union members, in their own interests as well as that of the community at large, will move to redress the balance. And that beyond all doubt would be a victory.

1000 lb Vacuum-Melting Equipment at Detroit

FOR some time, metallurgists and engineers have realised that metals and alloys processed by conventional methods have certain drawbacks often associated with the presence of unavoidable impurities or inclusions. The need to transform the melting and processing of metals and alloys from an art to a more exact science has long been recognised by the General Electric Company, and the necessity for superior metallic materials in many of its diversified products led the company to investigate the vacuum melting technique in 1946. During that year, a small pilot plant was placed in operation at the General Electric Research Laboratory in Schenectady, New York. Since that time, the laboratory and various operating departments, including the Carboloy department at Detroit, co-operated in producing and evaluating under experimental conditions an increasing number of metals and alloys.

What happens when one melts metals in a vacuum? With the closer composition control, the metals and alloys produced are free from inclusions or impurities. They experience less loss of critical alloying elements than in conventional practices where oxidation or undesirable side reactions occur. Sometimes, the process develops and produces a completely new family of metals and their alloys. For many existing alloys, melting in a vacuum so markedly improves their mechanical properties that these, too, can be classed as new alloys. Benefiting through vacuum melting, nickel and cobalt-base alloys, for example, undergo a minimum loss of hardening elements due to oxidation. Their superior cleanliness reflects substantially improved fatigue and stress rupture properties. Ductility and overall workability are so improved that fewer rejects are produced. In addition, the scrap has excellent remelt value. Vacuum melting also imparts similar properties to low-alloy steels. High-chromium alloys normally exhibit brittle fracture at room temperature. Producing these alloys with substantially lower transition temperature and, consequently, a greatly improved room-temperature impact strength, broadens their field of use. The reduction of dissolved gases in copper and nickel appreciably improves their use for electronic valve applications. The emission characteristics of cathodes of vacuum-processed metal are superior because of increased purity and closer control of composition. Copper melted in vacuum exhibits a conductivity close to 100 per cent of the calculated theoretical value. The process even improves the purity of iron. Vacuum-melted iron shows as much as 60 to 70 per cent greater resistance to rupture; and its elongation often increases as much as 400 per cent with comparable increases in tensile and yield strengths.

It is well known that the service life of bearings and springs frequently depends on the fatigue strength of the alloy they are made from. This strength, in turn, is closely related to metal or alloy cleanliness. Bearings of S.A.E. 52100 steel processed by vacuum techniques show a fourfold increase in service life. Tool and die steels of superior qualities also can be made by excluding dirt, or inclusions, through the process. The much lower inclusion content of vacuum-melted spring alloys makes it possible to draw wire to finer sizes, with improved surface finishes and fewer breakages. The presence of surface imperfections in parts of conventionally melted alloys often leads to galvanic corrosion or pitting during service. Usually a function

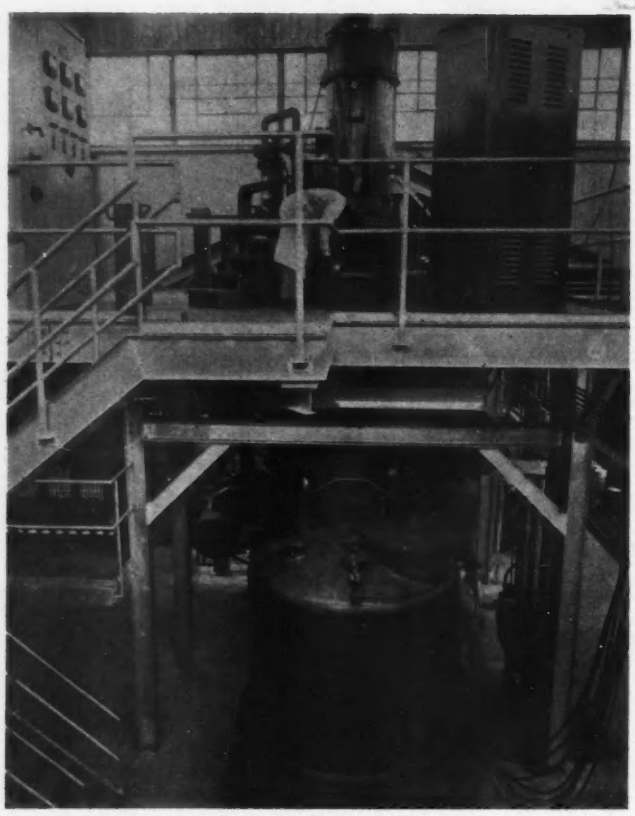


Fig. 1—1000 lb semi-continuous, high-vacuum melting and casting furnace The furnaceoperator is making alloy additions to the melt from the upper deck.

of purity, the overall corrosion resistance of various metals and alloys will undoubtedly improve substantially. The process may even render a less costly material suitable in current applications.

Modern vacuum melting equipment consists essentially of the furnace and the vacuum pumping system. A charge lock, cover, crucible and coil assembly, and a mould platform constitute the furnace. The pumping system varies, depending on the operating procedure and the materials being melted. Many American furnaces of 350 lb capacity, for example, operate with a 16in diffusion-ejector pump having a throughput of 40,000 micron-litres per second at a pressure of 10 microns or 2500 micron-litres per second at 1 micron. Such a system maintains the pressure necessary for a gas-free atmosphere and also provides enough pumping capacity for handling pressure surges that occur during alloy processing and pouring, and return the chamber quickly to the required operating pressure. A similar vacuum pump would be needed to increase this pumping capacity for a 1000 lb furnace, similar to the unit described below.

Using the vacuum melting process, General Electric succeeded in greatly improving "M-252," a high-temperature alloy, which was produced for several years by conventional melting. The metal is a nickel-base alloy strengthened with moderate amounts of titanium and aluminium. Developed for use in jet-engine buckets, it is now being utilised in other parts of the jet engine, as well as in other unrelated high-temperature applications. When made by the vacuum process, the mechanical properties of the alloy are appreciably enhanced. Furthermore, according to this company's experience it can be produced in a wide variety of useful mill shapes with excellent finish. In the past, converting expensive high-temperature alloys produced by conventional melting practices from ingot to bar stock averaged a 40 to 50 per cent recovery. To-day, with vacuum-melted "M-252," the recovery averages 60 to 70 per cent, producing much cleaner bar scrap with its hardening elements undiluted by oxidation. Thus, the scrap can be remelted without appreciable loss of properties.

Melting high-temperature alloys in air limits the addition of hardening elements, such as titanium, molybdenum, zirconium, boron, and others. Titanium, for example, is limited to about 2·5 per cent. Vacuum or controlled atmosphere induction melting permits these percentages to be raised to produce alloys of greater ductility and strength to withstand higher operating temperatures. This promises to create a new family of high-temperature alloys with even better mechanical properties. For example, the recently developed alloy "1570" contains about 4 per cent titanium—an amount beyond the point that can be melted in air. Extremely difficult to melt in air with the desired properties, this alloy has superior strength at high operating temperatures when it is melted in a vacuum furnace.

Vacuum melting requires great flexibility of equipment to meet specific needs. For example, the equipment must be designed to allow interchanging the bottoms of the vacuum chamber or adding another pumping system to handle larger poundages. This makes cleaning easier, simplifies repairs in the event of spill-outs, and offers alternate methods of casting. The new 1000 lb furnace (Figs. 1 and 4) which recently went into operation at the Carboloy Department of the General Electric Company, is representative of an installation that not only provides flexibility of operation but also lends itself to expanded capacity. Built by the Consolidated Vacuum Corporation, of Rochester, New York, it can at present produce two 1000 lb heats per shift. Of the so-called modular design, its operation can be expanded or curtailed, much in the manner of building blocks.

By providing various chamber bottoms with suitable accessory equipment, the same furnace produces single ingots, multiple-shaped castings, or centrifugal castings. Semi-continuous operation is provided by interlocks through which the crucible can be charged, the alloying elements altered, and the ingots removed without breaking the vacuum in the main chamber. Basically, the three systems making up the units are so inter-related that one operator can handle the main furnace and the auxiliary operations. Three control panels co-ordinate all functions of the power and the air-evacuating systems with those of the furnace itself. One panel which is used strictly for power purposes, balances out the capacitor banks of the 350kVA motor-generator set supplying power for induction heating. The second panel controls the vacuum system and includes a schematic diagram of the vacuum lines tied in with indicating lights, keeping the operator informed at all times. This panel lends considerable flexibility to the system by controlling or shutting off any section when necessary. The smallest panel acts as an index for the turntable that holds the moulds and the mechanism that raises them into the

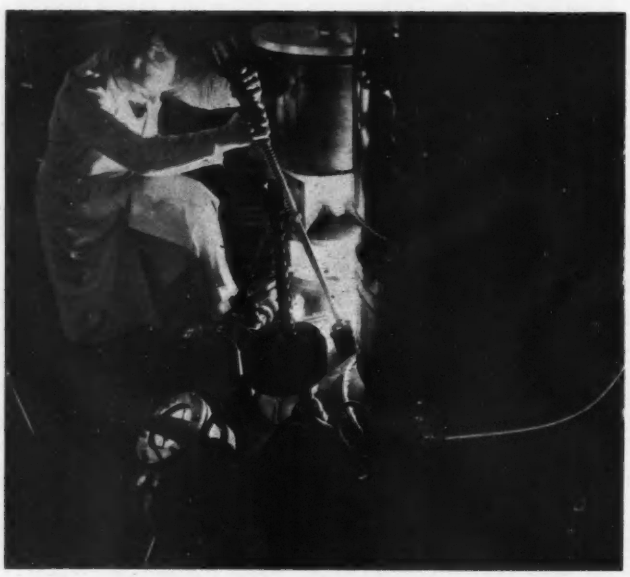


Fig. 2—Vacuum-furnace operator employing a self-sealing sampling device to pull a slug from the melt for analysis control

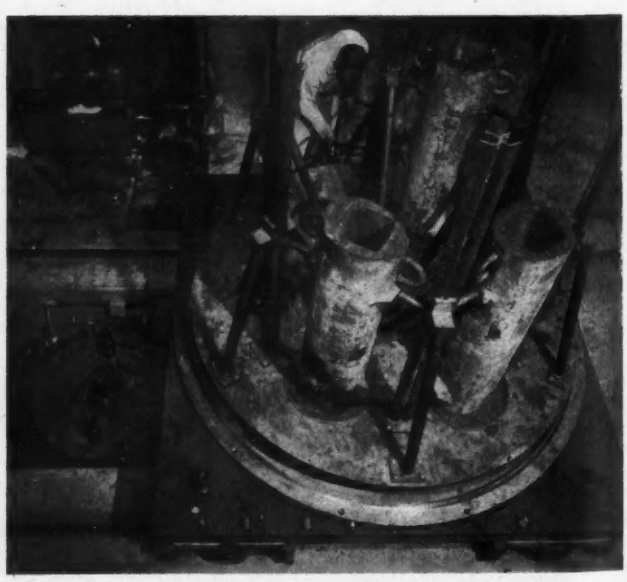


Fig. 3—Track-mounted platform and turntable carrying three ingot moulds. Hydraulic mould lifting mechanism at the left

main furnace chamber section for pouring. Three pumps—two roughing and one oil diffusion units—are included in the air-evacuating system. They can be operated simultaneously or individually. One of the roughing pumping systems handles the furnace operation alone. However, the addition of another pumping unit increases the furnace efficiency and speed and primarily expels air from various chambers as the operations demand. While the roughing pumps lower pressures to about 500 microns, extremely low pressures of less than a micron are obtained when using the oil-diffusion pump. The control panels as well as other operating equipment are situated near the top of the furnace. Here also are found an immersion thermocouple for controlling pouring temperature and a sampling device with equipment for inserting certain working tools into the furnace as necessary. The water-cooled tilting induction furnace used for melting is mounted on a trunnion inside a stainless steel tank. The introduction of power to the furnace by means of a coaxial arrangement eliminates the use of flexible leads.

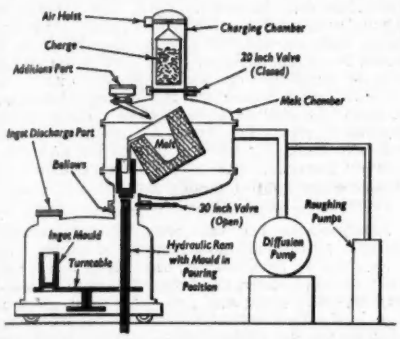


Fig. 4—General arrangement of 1000 lb semi-continuous, high-vacuum melting and casting furnace

When power is needed, air-actuated shoe contacts are clamped on to the water-cooled coaxial cable, making the electric contact. In this arrangement, power can be cut off for pouring or turned on again when the furnace is locked in the tilted position. Two levers control the movement of the induction furnace : horizontal movement of one engages the first of two micro-switches that de-energises the capacitor bank. When the lever in its continuing movement engages the second micro-switch, the latter activates an air cylinder that disengages the contacts. The other lever tilts the furnace after the locking pins are removed.

Charging cans, about the size of a large dustbin, are filled with the desired metallic elements for the melt in predetermined amounts. Because the can also melts, the container is selected for what it will contribute to the analysis of the melt. For example, if an appreciable iron content is permitted, an iron container can be used. The filled container is lifted to the top of the vacuum melting furnace and hooked on the inside top cover which is in a raised position. After replacing the cover, a windlass arrangement lowers the charge in the charging chamber. At this point, the charging chamber is sealed, and a roughing pump evacuates the air from the chamber. Lowering the pressure sufficiently takes a matter of minutes. A pneumatically-operated sliding valve under the chamber opens and the charge continues its descent to be positioned in the crucible of the induction furnace. Then the hook is disengaged and hoisted out of the way ; finally, the valve is closed.

Once the melt starts, the charging chamber can again be made ready with a second charge. Melting, ranging in temperature from 2800 deg. to 3200 deg. Fah., takes about one hour. Including refining, the total cycle requires about five hours. As melting continues the shrinkage of the original charge necessitates making bulk additions through a separate valved-off charging lock to bring the heat up to capacity. After the additions are made, a pump roughs out ; and when the pressure is lowered sufficiently, the charge is dropped on to a vibratory chute leading to the furnace. During the melt, considerable gas is generated and pumped out continuously until the pressure drops to a predetermined level. Impinging hydrogen gas directly on the liquid bath reduces oxides, and the resulting water vapour is also continuously pumped out. This reaction process continues for about an hour, to arrive at reasonable completion. Late additions, such as highly reactive zirconium, titanium, and aluminium, follow this phase of the melting process. Operation of the self-sealing sampling device is shown in Fig. 2. After the hydrogen is cut off, the melt is evacuated until it reaches a reasonable pressure, when it can be poured.

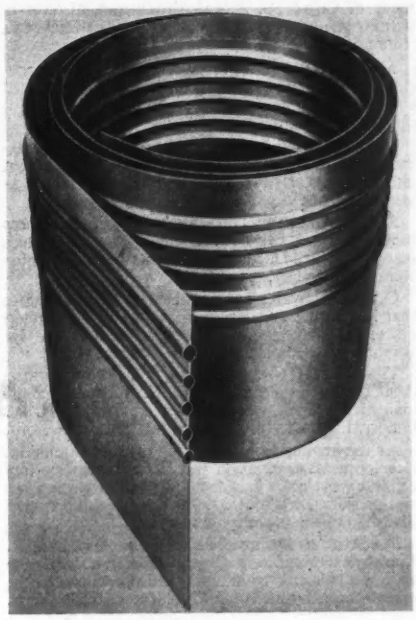
The ingot moulds for pouring rest on a turntable that forms the bottom of a large bell-shaped container, or jar, mounted on a platform that runs on tracks. At pouring time, this huge jar is pushed into position and spotted under a 30in valve that leads to the induction furnace. Then, through a bellows arrangement on top of the jar, the flange is raised to meet the 30in valve. After sealing the connection and evacuating the jar with the roughing pump, the 30in valve is then opened and the turntable indexes the mould. A lift raises the mould through the valve into pouring position in the main chamber. After pouring, the hot ingot is then lowered into the bell jar and the operation is repeated by indexing the turntable. The heats in the furnace can be divided into as many as six ingots before disengaging the ingot platform. This platform (Fig. 3) handles moulds for any size of ingot ranging from 100 lb to 1000 lb, and is equipped for hot topping. Adjustable electrodes inside the jar are used for hot topping and they can be lowered into contact with the metal while cooling. Then the ingots are stripped from the moulds and allowed to cool.

Tube-in-Strip Material for Heat Exchange Applications

AN interesting mill product in the form of a single strip, or sheet, of solid copper, brass or aluminium in which tubes are inflated to desired running lengths in a variety of shapes or sizes has been developed by Revere Copper and Brass, Incorporated, of New York. Known as " Tube-In-Strip," the new product is said to have almost immediate applications in the heat exchange field, including refrigeration and air conditioning, chemical, food and petroleum processing, automobile radiators, radiant panel heating, and electronics. The product is made by incorporating strips of a friable material which is inert chemically with respect to the material being processed in the billet casting and then rolling the casting into plate.

As now produced at the works of the company, these coils and sheets of " Tube-In-Strip " are not discernibly different from the standard sheet and strip products normally produced in the rolling mill. However, the new material has incorporated within it expandable portions which can be inflated by the user into continuous running lengths of tube of whatever size and spacing or combinations of sizes and spacings might have originally been designated. Except for the expandable portions, the metal is a solid strip of metal derived from a suitably treated casting and, unlike the roll-bonded materials of the Olin Mathieson Chemical Company and the Reynolds Metals Company, the product does not consist of two pieces of metal brazed, welded and rolled together. The metal can be stamped or drawn into desired shapes prior to the expansion of the channels. The expanded channels can be made circular in section, or during the expansion operation the metal can be forced into dies for the purpose of producing other than circular sections. It is also possible to inflate the channels on one side of the strip or sheet only, leaving the other surface flat. The basic method of producing this material is covered by pending patent applications, and manufacturing procedures have already been developed for copper and brass, the copper base alloys in general, aluminium and aluminium alloys, zinc and other ferrous and non-ferrous metals.

" Tube-In-Strip " can be furnished exactly as other sheet metal mill products, in long coils or in cut flat sheets in widths up to 16in at present, the determining factor being the size of the casting billet from which the product is rolled to its desired width or gauge. The tube spacing can be generally as close as $\frac{1}{4}$in and as widely apart as the width of the metal permits. The inside diameters of the tubes can vary from approximately $\frac{1}{16}$in to $\frac{1}{4}$in inclusive, when expanded. The tube wall gauge can vary from 0·0025in to whatever the inflation equipment permits. The firm plans to despatch " Tube-In-Strip " to the consumer uninflated. This method is possible because the inflation techniques are flexible and generally simple. Thus, for thin-walled tube air pressure may be entirely adequate, while for heavy walls hydraulic means of inflation should be employed. All tubes in a given width of strip can be inflated simultaneously or otherwise, as desired. Free inflation produces a wholly round tube. A profile die, or free inflation between flat plates, holding the metal in restraint, is used to obtain dimensions and contours other than round. Stamping, forming, bending and drawing operations can be performed on " Tube-In-Strip " before inflation. Furthermore, the new product can be inflated before bending, perforation and similar operations and then further processed by common pipe and tube bending techniques. Manifolds, for either series or parallel flow, are easily produced either before or after inflation, and return bends can be brazed, soldered or welded readily.



Coil of tube-in-strip material showing inflated tubes

Miniature Strain Gauge Load Cells

A SERIES of miniature Baldwin SR-4 load cells for the electrical measurement of forces and weights up to 10,000 lb in compression have been developed by the Baldwin-Lima-Hamilton Corporation, of Philadelphia, Pennsylvania, for use where space is severely limited. These cells are less than 2in in diameter and only $2\frac{1}{2}$in high overall. Special cells with capacities ranging from 2000 lb to 10,000 lb have been built for a specific application. These cells are not intended to replace the larger cells of the same capacities and of greater accuracy of measurement. The small size of these special cells was provided at a sacrifice in side load sensitivity. They were developed to measure thrust forces in large steam turbines but may be used wherever space is too limited to permit the use of the standard cells of larger size. The calibration accuracy is said to be within plus or minus $\frac{1}{4}$ per cent of full range at any load at 70 deg. Fah. and the resistance across power terminals is 120 ohms.

Personal and Business

Appointments

COLONEL R. P. W. ADEANE has joined the board of The Ruberoid Company, Ltd., 1–19, New Oxford Street, London, W.C.1.

MR. RALPH HUSSEY has been appointed sales manager in the boiler division of Elliott Brothers (London), Ltd., Century Works, Lewisham, S.E.13.

THE MINISTRY OF SUPPLY announces the appointment of Colonel J. A. Fitzpatrick as a director of fighting vehicles in succession to Brigadier C. W. M., Timmis.

MR. S. F. STEWARD, managing director of Lancashire Dynamo Holdings, Ltd., has been appointed chairman of Lancashire Dynamo Electronic Products, Ltd.

THE BRITISH OIL BURNER MANUFACTURERS ASSOCIATION, Ltd., has elected Mr. J. R. C. Boyce as president and Messrs. J. D. Fitzgerald and W. A. Hubbard as vice-presidents.

SMITHS AIRCRAFT INSTRUMENTS, Ltd., announces the appointment of Mr. J. S. Rivers as technical sales manager. Mr. D. G. Johnson has been appointed contracts manager.

G. AND J. WEIR, Ltd., Cathcart, Glasgow, states that Mr. Andrew C. Smith, manager of the London office, has been appointed an executive director. He is returning to Cathcart as sales director.

THE BRITISH CHEMICAL PLANT MANUFACTURERS ASSOCIATION has elected Mr. G. N. Hodson as chairman and the new vice-chairmen are Messrs. H. W. Fender, I. M. O. Hutchinson and R. W. Rutherford.

AT the annual general meeting of The Aluminium Development Association the Honourable Geoffrey Cunliffe was elected president and Mr. Spence Sanders vice-president, while Mr. J. H. Mayes was appointed chairman of the executive committee.

BLACK AND DECKER, Ltd., states that Mr. R. Appleby, director and general manager, has been appointed director of international operations to the parent company at Towson, U.S.A. Mr. J. W. A. Meredith has been appointed export sales manager.

THE BRITISH TRANSPORT COMMISSION has announced the following appointments to the central staff of British Railways :—Mr. E. Claxton, A.M.I.C.E., A.M.I.Mech.E., assistant electrical engineer (development) ; Mr. W. J. Webb, A.M.I.E.E., assistant to electrical engineer (systems).

THE BRUSH GROUP, Ltd., has announced the appointment of Mr. Geoffrey Eley as chairman, following the retirement of Sir Ronald Matthews. Mr. Miles Beevor becomes deputy chairman and joint managing director, and Mr. Ian T. Morrow has been appointed a joint managing director.

HICK, HARGREAVES AND CO., Ltd., Bolton, announces the appointment of Mr. F. L. Donnison, A.M.I.Mech.E., as chief engineer, in succession to Mr. G. Arrowsmith. Mr. Arrowsmith is retiring at the end of the month, after thirty-three years' service ; he will continue to serve on the board of the company.

THE LORD PRESIDENT OF THE COUNCIL has announced the appointment of Sir Harry Jephcott as chairman of the advisory council of the Department of Scientific and Industrial Research. He succeeds Sir Hugh Beaver, who has expressed a wish to relinquish the chairmanship, but who will continue to serve on the council.

KEITH BLACKMAN, Ltd., Mill Mead Road, Tottenham, N.17, states that Mr. D. S. Woodley, M.I. Mech.E., managing director, is to succeed Mr. M. Burningham as chairman. Mr. Burningham will complete sixty years' service with the firm on June 16th and has expressed a wish to retire from the chairmanship and from the board of the company.

MR. H. P. POTTS has been appointed managing director of the B.S.A. Small Heath Group in succession to Mr. James Leek, who is retiring. Mr. Potts will continue as managing director of the B.S.A. Tools Group. Mr. S. A. Roberts has been appointed deputy managing director of B.S.A. Tools Group. Mr. T. N. Woof has been appointed general manager, and Mr. F. A. Janes, sales director, of Burton Griffiths and Co., Ltd.

TECALEMIT, Ltd., Plymouth, has announced the following appointments :—Mr. L. R. Hedgcock, divisional manager (regions), with Mr. G. W. Ely as his assistant ; Mr. D. A. Monaghan, manager of the London and Midland region ; Mr. J. J. Bell, manager of the Scottish and Northern Ireland region ; Mr. J. E. Drinkwater, deputy general factory manager ; Mr. E. G. Simmons, technical manager ; Mr. R. R. Parker, manufacturers' divisional manager ; Mr. D. G. Thorp, motor manufacturers' representative ; Mr. J. G. H. Maxfield, industrial manager ; Mr. D. M. Bruce, sales administrator.

Business Announcements

BORG-WARNER, Ltd., Letchworth, Herts, has acquired the shares of Hartcliffe, Lee and Malkin, Ltd., Salford, Lancs.

DAVIS SHEET METAL ENGINEERING COMPANY, Ltd., states that its address is now Eley's Estate, Angel Road, Edmonton, N.18.

F. PERKINS, Ltd., Peterborough, has handed over a mobile instruction school to Intercommerce, Belgrade, its distributor in Yugoslavia.

THE EXPORT CREDITS GUARANTEE DEPARTMENT has moved its headquarters to 59, Gresham Street, London, E.C.2 (telephone, Monarch 6699).

FIELDEN ELECTRONICS, Ltd., Wythenshawe, Manchester, states that A. R. Bolton, Ltd., 72, Haymarket Terrace, Edinburgh, 12, is its sole agent in Scotland.

WOLF ELECTRIC TOOLS, Ltd., has acquired the property at 47, Barker Street, Birmingham, 19, in order to extend its Birmingham sales and service branch.

SUNDERLAND SHIPBUILDING DRY DOCKS AND ENGINEERING COMPANY, Ltd., has taken over Wear Winch and Foundry Company, Ltd., Commercial Road, Sunderland.

MOBIL OIL COMPANY, Ltd., has announced the retirement, after thirty years in its service, of Mr. D. T. McHutchison. He has been senior engineer in the Scottish division since 1938.

PEGSON, Ltd., Coalville, Leicestershire, has completed arrangements to manufacture under licence in this country the asphalt and bituminous macadam plants built by Wibau, Gelnshausen, Germany.

F. E. CALLOW (ENGINEERS), Ltd., Kirkby Trading Estate, Liverpool, announces that its arrangements have now been completed for representing as sole agent in the British Isles the firm of Libra Pelz and Nagel K.G., Braunschweig-Gliesmarode, German Federal Republic, manufacturer of weighing machines for flour, cattle foods and chemicals, in particular non-free-flowing materials.

Contracts

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has been awarded the contract for the building of the Independent Television Authority's second Northern television station at Emley Moor, near Huddersfield. The Marconi Company has also received an order from the U.S.S.R. to supply a quantity of television equipment.

WHESSOE, Ltd., Darlington, has received an order from the Argentine State Gas Department for two electro-detarrers for Buenos Aires. These detarrers, which are 9ft in diameter, are complete with two high-tension transformer rectifier sets, each of 180MA at 33kV. The complete plant has a capacity of over 1,000,000 cubic feet per hour of water gas measured at S.T.P. and treated at approximately 40 deg. Cent.

THE ENGLISH ELECTRIC EXPORT TRADING COMPANY, Ltd., has received a contract from the Department of Water and Power of the City of Los Angeles for two three-phase, 18,000/140,000V, 60 c/s, 200,000kVA power transformers, together with spare parts. This contract is valued at approximately 500,000 dollars. The transformers are to be installed at the Scattergood Steam Plant, California, and will be designed and manufactured at the Stafford works of the English Electric Company, Ltd.

Miscellanea

HORIZONTAL OIL ENGINES.—Davey, Paxman and Co., Ltd., announces that the range of the company's 7in. by 7½in horizontal oil engines for railcars has been extended and now consists of four and six-cylinder units in four variations. Mark 4 ZH develops 200 b.h.p. and 300 b.h.p. when pressure charged, while the Mark 6 ZH engine is rated at 300 b.h.p. and 450 b.h.p. when pressure charged. All engines run at 1500 r.p.m.

SPARK EROSION MACHINING MOBILE DEMONSTRATION UNIT.—As a result of the increasing interest in machining by the spark erosion method, Burton, Griffiths and Co., Ltd., Kitt's Green, Birmingham, has placed a mobile unit in service to demonstrate "Sparcatron" equipment. This equipment is mounted on an Austin van with a special body, and power for operating it is generally taken from the supply of the factory being visited. Should power not be available a self-contained generating set installed in the van can be used. Stabilising jacks are fitted fore and aft of the chassis to prevent rocking of van when the equipment is in operation.

GEAR MANUFACTURERS' ASSOCIATION.—At the annual general meeting of the Gear Manufacturers' Association in London on Tuesday, May 15th, a paper entitled "Some Aspects of the Loading of Gears and Roller Bearings" was presented by Mr. W. J. Davies, chief transmission engineer of the aero division of Rolls-Royce, Ltd. At the luncheon which followed the presentation of the paper Dr. H. E. Merritt said that research workers too often failed to take note of what was actually required by industry ; he pointed out that the gear making industry was still in need of a great deal of essential information. Much work had been done on gear development, but the information available was not always easy to obtain and there was an urgent need for it to be collected if full benefit was to be derived from the work already carried out.

PRECISION GRATICULE FOR UNIFIED THREAD FORMS.—A new graticule for the measurement of unified thread forms using the O.M.T. toolmaker's microscope has been introduced by Optical Measuring Tools, Ltd., Bridge Road, Maidenhead. This graticule is manufactured to B.S.S. 1580 : 1953 and the maker states that a National Physical Laboratory report indicates that the accuracy possible using it would be of the order of 0·00017in, as compared with the 0·0005in tolerance for thread forms being measured permitted in the N.P.L. specification of accuracy of a toolmaker's microscope. The graticule completely covers the thread forms for both nuts and bolts from four to forty threads per inch. To simplify inspection and to eliminate possibility of confusion the forms for bolts and nuts are imaged in separate sections of the graticule.

AIR-OPERATED PORTABLE SPOT WELDER.—A new portable air-operated spot welding machine now being made by Ring Motors, Ltd., Ayres Road, Old Trafford, Manchester, can be supplied with an overhead balanced suspension unit and a sling, giving a high degree of manœuvrability without undue physical effort on the part of the operator. It is designed for 10,000A, 20kVA, 360–480V and an operating air pressure of 80 lb per square inch. A two-stage electronic timer gives a timing range of 1 to 60 cycles, and metals from 22 by 22 gauge up to 10 by 10 gauge can be spot welded without any adjustments other than to the timer. When the machine has been placed in position depression of a trigger switch actuates an air valve and the electrode arms close to exert a pressure of up to 750 lb on the work. The timer is then automatically initiated by the air control and current is switched on for the predetermined period to weld the work.

TOOL STORE RACKS.—A new form of tool store rack developed by Randalrak, Ltd., 106, Victoria Street, London, S.W.1, is designed to facilitate the storage of tools in the minimum space and reduce the risk of damage. It is known as "Peg-shelving" and uses a special form of shelf and racks which are available in a number of different heights. The shelves are in the form of shallow drawers, the floors of which are drilled with a pattern of holes into which pegs can be fitted. The tools to be stored are placed on the shelves and pegs placed round them to prevent movement when the shelves are slid in and out on the racks. The number or identity mark of the tool is painted on the front of the shelf. The racks are fitted with runners and their support members can be adjusted to give any desired distance at 2in or 4in pitch between the shelves. Shelves can be supplied with a stove-enamelled finish, coated with polythene or fitted with a rubber base mat to prevent damage to the tools.

DRYING OF MOULDS BY PORTABLE DRYERS.—The report of the Technical Sub-Committee of the Joint Standing Committee on Conditions in Iron Foundries has been published under the title "The Drying of Moulds by Portable Dryers." The report contains thirty-one recommendations, dealing with the design of dryers and their use, and it examines the whole subject of combustion in portable mould dryers. The Joint Standing Committee was set up following the recommendation in 1947 of the Joint Advisory Committee that an ordinary open fire should not be used for mould drying, other than in exceptional cases where it was unavoidable. The advisory committee had pointed out the advantages of coke-fired portable mould dryers and it thought that even though they were not fitted with flues to take away the products of combustion, good combustion was ensured as they were blown either by fans or by compressed air. Provided the dryers were suitably constructed and properly maintained and operated, it was thought there would be little risk of injurious or offensive fumes or smoke being given off. In its report the Technical Sub-Committee discusses fully experimental work which confirms the opinion expressed in 1947 by the Joint Advisory Committee.

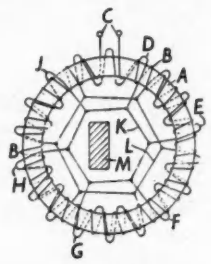
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

ELECTRICAL ENGINEERING

740,467. February 2, 1953.—CURRENT TRANSFORMERS, Foster Transformers, Ltd., South Wimbledon, London, S.W.19; Thomas Courtney, 48, Ravensfield Gardens, Ewell, Surrey; and Anthony Herbert Green, 48, Montague Gardens, Wallington, Surrey.

The invention provides an arrangement of a current transformer whereby a greater degree of accuracy and uniformity of the current transformation ratio is obtained. In the drawing the invention is shown applied to a toroidal core transformer. The core *A* carries a secondary winding *B* between terminals *C*, the winding being wound uniformly over the core to occupy substantially the whole length. Six auxiliary windings *D* to *J* are provided, which are all connected in parallel by conductors *K* and *L*, but



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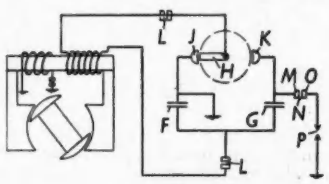
are not connected to any external circuit. The primary conductor is shown at *M* and this may be asymmetrically placed without loss of accuracy. The number of auxiliary winding sections may be more or less than six according to accuracy requirements. Further, the core *A* may be of a different type than that shown. In the case of a transformer without a primary element appropriate means may be provided to enable the core to be opened to admit the conductor *M*.—*November* 16, 1955.

740,788. September 7, 1953.—AN ELECTRIC SPARK IGNITION SYSTEM, Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (*Inventor: Brian Gilbert.*)

The invention has for its object to provide in a simple and effective form, an electric spark ignition system for producing sparks at a sparking plug and suitable for use more particularly on a jet propulsion engine or gas turbine, but applicable also to other analogous uses. Referring to the drawing, the



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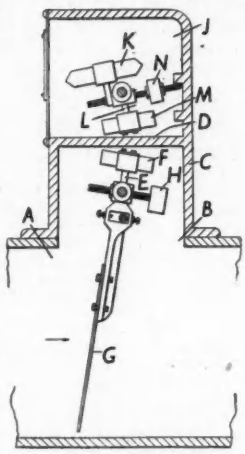
arrangement shown includes a rotary magneto for providing successive high-tension discharges of alternately opposite sign. The magneto serves to charge a pair of similar condensers *F* and *G*. Between the other sides of the condensers is arranged a distributor which comprises a rotary arm *H* driven at the same speed as the magneto and a pair of stationary electrodes *J* and *K*, 180 deg. apart, connected to the two condensers. The arrangement is such that each positive discharge from the magneto or alternator is conveyed to one of the condensers, and each negative discharge to the other condenser. To minimise loss of charge from the condensers by leakage a small insulating spark gap *L* may be inserted at either of the positions shown. The distributor arm *H* may be arranged to wipe across the electrodes *J* and *K* or it may deliver the successive discharges across the small air gaps between it and the electrodes. A point between the electrode *K* and the condenser *G* is connected to one of the electrodes *M* of a control gap *N*, the other electrode *O* of the control gap being connected to the ignition sparking plug *P*. The system described is such that successive high-tension discharges of opposite sign generated by the magneto or alternator are respectively conveyed in succession to the two condensers, until the sum of the voltages of the condenser equals the breakdown voltage of the control gap *N*. The condensers then both discharge across the control gap to the sparking plug. Successive charging and discharging of the condensers is continued so long as it is required to keep the sparking plug in action.—*November* 16, 1955.

741,484. January 29, 1953.—GAS-FLOW-RESPONSIVE ELECTRIC SWITCH DEVICES, John Kenrick Haynes, "Cragside," 46, The Green, Ewell, Surrey.

The invention relates to electric switch devices operated by the flow through a conduit of gas. It provides access to the switch mechanism without the risk of explosion or fire. As seen in the drawing, a conduit *A* through which inflammable vapour is driven is furnished with a lateral aperture *B* covered by a cap-shaped casting *C* composed of non-magnetic material and embodying a closed wall *D*. Beneath the wall is pivoted a rocking lever *E*, the upper end of which carries rigidly a permanent magnet *F*, whilst the lower end has a vane or flap *G* in the path of the gas. The lever *E* has a counterbalance weight *H* for adjusting leverage so that when the gas is passing at any rate



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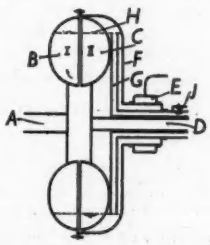
exceeding a predetermined figure the vane *G* is moved forward and the lever *E* is tilted counter-clockwise. Above the wall *D* a cavity *J* houses a mercury switch *K* on a lever *L*, the lower arm of which carries a permanent magnet *M* similar to the magnet *F*. The two magnets *F* and *M* are disposed one above the other and separated by the solid wall *D* of the casting *C*, the polarity of the magnets being such that counter-clockwise movement of the vane-carrying lever *E* effects clockwise movement of the mercury switch lever *L*. An adjustable weight *N* is provided for the lever. When the flow of gas exceeds a predetermined figure and the vane-carrying lever *E* occupies its counter-clockwise position, the mercury switch *K* is arranged to hold closed the circuit of a motor driving the fan, but should the rate of flow fall below this figure the vane-carrying lever will move into clockwise position, thereby moving the mercury switch lever *L* into its counter-clockwise position, as shown, to open the circuit of the fan motor.—*December* 7, 1955.

POWER TRANSMISSION

748,146. June 19, 1953.—HYDRAULIC CLUTCHES, The Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany. (*Inventors: Karl Kollmann and Ulrich Eltze.*)

The invention concerns improvements relating to hydraulic clutches, particularly for motor vehicle drives, in which the state of filling of the clutch can be controlled or regulated. It aims principally at effectively preventing so-called "creeping" of the



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vehicle when the engine is idling. In the drawing, *A* is a shaft driven by an engine, *B* the primary part, and *C* the secondary part of a hydraulic clutch, and *D* the output shaft of the clutch. Liquid is supplied to the clutch by a pump which draws the liquid from a vessel, such as the clutch housing, and delivers it through a duct to the inlet chamber *E* of the clutch. Thence the liquid can pass into the interior of the clutch cover *F* rotating with the primary clutch part *B* and can fill the working space of the clutch through the outer gap between the two parts *B* and *C*. As illustrated in the drawing, one or more stationary scoop tubes *G* disposed in the housing extend outwards in the radial direction to a desired liquid level *H* in the clutch. A valve *J* controlled in dependence on the vehicle speed or the speed of the clutch part *C* by a centrifugal governor or by hydraulic means, opens when the vehicle speed or the speed of the part *C* falls below a predetermined minimum. On the opening of the valve, the clutch is emptied as far as the level *H* by the action of a return pump. Thus, when the vehicle or the clutch part *C* is running at low speed or is at rest, with the engine idling, the working space of the clutch is automatically emptied at least until the quantity of liquid remaining is insufficient for the transmission of a residual torque capable of imparting a drive, for example, so-called "creep," to the vehicle. When the speed rises, however, the valve *J* closes and the clutch is rapidly filled by the pump so that the full torque can be transmitted. In the specification four other modifications of the design are shown.—*April* 25, 1956.

TOOLS AND WORKSHOP APPLIANCES

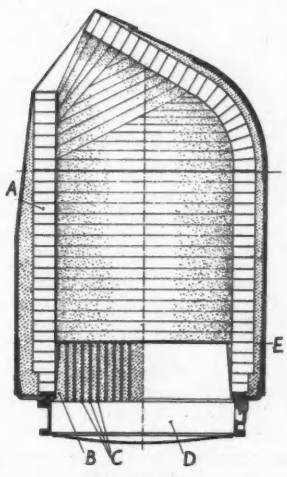
748,014. April 9, 1952.—A METAL WORKING TOOL, Gebr. Bohler and Co. Aktiengesellschaft, Elisabethstrasse 12, Vienna 1, Austria.

The invention relates to a metal working tool, the object of which is to have a great resistance to wear due to friction, without affecting other important physical properties. According to the invention, the tools consist of the steel alloys usual for metal working, for example, high-speed steels, but for the purpose of improving their essential metal working properties, more particularly machining properties they have an addition of sulphur of up to 1 per cent in the form of molybdenum sulphide, manganese sulphide or lead sulphide. It has been found that molybdenum sulphide, manganese sulphide and lead sulphide are materials which do not undergo contact welding (so-called cold welding) either with the tool or with the worked metal, and thus prevent binding of the metal working tool. The lead sulphide, manganese sulphide or molybdenum sulphide can be added singly or together. In order to ensure the desired effect of the additions according to the invention it is necessary that they be uniformly distributed in the tool.—*April* 18, 1956.

CONVERTERS

748,271. November 11, 1952.—IMPROVEMENTS IN BESSEMER OR THOMAS CONVERTERS, Institute de Recherches de lá Siderurgie, 185, rue Président Roosevelt, Saint-Germain-en-Laye, Seine & Oise Department, France.

The invention relates to improvements in Bessemer or Thomas converters for improved blowing. The converter shown in the drawing comprises a substantially cylindrical lining *A* extending vertically from the bottom *B*, through which pass the tuyeres *C*, up to the height corresponding to the portion forming the mouth. The bottom *B* is arranged above the



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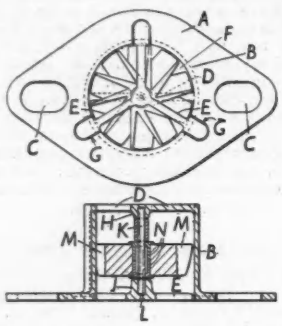
wind-box *D*. The converter being, at the bottom, wider than the conventional converters, the steel shell *E* is designed with a larger size at the lower portion in order to surround the lining and the bottom properly. The converter shown is new since its shape has been entirely modified and the area of the bottom through which the tuyeres pass is equal to the area

obtained by cutting the converter when new by a plane parallel to the bottom, at the place where that area is maximum, less the area of the joint between bottom and lining. Several modified designs are also shown in the specification.—*April* 25, 1956.

INTERNAL COMBUSTION ENGINES

748,352. May 2, 1953.—FUEL ATOMISERS, Francis Reginald Chatwin, 846, Alum Rock Road, Ward End, Birmingham, 8.

The invention has reference to fuel atomisers fitted in the induction system of an internal combustion engine for improving the atomisation of the petrol vapour and mixing the vapour with air, thereby



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minimising fuel consumption. The atomiser shown in the drawing comprises a gasket *A* having a central aperture which opens into an open-ended cylinder *B*. The gasket has elongated holes *C* to enable it to be secured between the flanges normally provided on the inlet to the induction manifold of an engine, the diameter of the cylinder being a close fit within the bore of the manifold. A bridge piece *D* is at the open cylinder end remote from the gasket, and a spider *E* is secured in the aperture *F*. The legs of the spider are secured in pockets *G* formed in the side of the gasket opposite to the cylinder *B*. Bosses *H* and *J* on the bridge piece and the spider are each formed with a pocket in which the spindle *K* is secured. The spindle end secured within the hub of the spider is of D-section and a hole *L* in the hub opens into the space between its face and the wall of the pocket in which it is held. A rotor, having ten blades *M* is rotatably carried by the spindle. The rotor is carried on a two-piece bearing sleeve *N* of oil-impregnated metal and turns freely on the spindle. The D-section portion of the spindle extends into the end of the bearing sleeve for a lubricant to be fed through the hole *L*. The rotor blades are each inclined at an angle of 45 deg. to 46 deg. to the rotor axis and each is of a depth not exceeding $\frac{1}{4}$in. Various types of rotors and an alternative design of atomiser are also shown in the specification.—*May* 2, 1956.

Launches and Trial Trips

CITY OF WINNIPEG, cargo liner; built by The Caledon Shipbuilding and Engineering Company, Ltd., for Ellerman Lines, Ltd.; length overall 507ft 3in, breadth moulded 65ft 6in, depth moulded to shelter deck 42ft, deadweight 10,500 tons; service speed 15 knots; five holds, one 70-ton, two 12-ton, six 10-ton, four 7-ton, and four 5-ton derricks, electric deck machinery; one 320kW and two 240kW diesel-driven generators; Wallsend-Doxford oil engine, six cylinders, 750mm diameter by 2500mm combined stroke, 8000 b.h.p. at 105 r.p.m., two vertical Cochran boilers.—Trial, March 22nd.

ASTRID NAESS, oil tanker; built by the Netherlands Dock and Shipbuilding Company for the Nederlandse Norness Scheepvaart Maatschappij, N.V., Amsterdam; length overall 614ft 6in, length between perpendiculars 580ft, breadth 76ft 6in, depth 42ft 6$\frac{1}{2}$in, deadweight 24,700 tons, loaded draught 32ft 9in, service speed 15 knots; thirty cargo oil tanks; N.D.S.M.-Stork single-acting, two stroke diesel engine, eight cylinders, 750mm diameter by 1500mm stroke, 8000 h.p. at 115 r.p.m.—Launch, April 6th.

ELIN KNUDSEN, oil tanker; built by Harland and Wolff, Ltd., for Knut Knutsen, Norway; length overall 665ft, length between perpendiculars 630ft, breadth moulded 85ft 6in, depth moulded 46ft 8in, deadweight 32,000 tons on 35ft summer draught; thirty oil cargo compartments, one cargo pump room, steam deck machinery, three 350kW diesel-driven generators, two 60kW motor-driven generators; one set of double-reduction geared compound turbines, 12,500 s.h.p. at 112 propeller r.p.m., steam supplied at 450 lb per square inch and 750 deg. Fah. by two oil-fired Babcock and Wilcox water-tube boilers. Trial, April 12th.

NONIA, cargo and passenger ship; built by Hall, Russell and Co., Ltd., for Canadian National Railways; length between perpendiculars 199ft, breadth moulded 35ft, depth moulded 19ft 6in, deadweight 1000 tons; 50 first-class and 40 second-class passengers; three holds, electric deck machinery, two 100kW diesel-driven generators and one 50kW auxiliary generator; Fairbanks-Morse opposed-piston diesel engine drives through a hydraulic coupling and reverse reduction gearing, 12,800 b.h.p. Launch, April 10th.

KAIMIRO, cargo liner; built by Alexander Stephen and Sons, Ltd., for the Union Steam Ship Company of New Zealand; length 350ft, breadth 50ft, depth 26ft, deadweight 5300 tons; three hatches, twelve derricks, and one to lift 25 tons, electric deck machinery; Stephen-Sulzer single-acting diesel engine, six cylinders, 600mm diameter by 1040mm stroke, 2410 b.h.p. at 128 r.p.m. normal power, overload power 3000 b.h.p. at 150 r.p.m. Trial, April 11th.

CLAN ROSS, cargo liner; built by The Greenock Dockyard Company, Ltd., for the Clan Line Steamers, Ltd.; length between perpendiculars 465ft, breadth moulded 65ft 6in, depth moulded to upper deck 39ft 7$\frac{1}{2}$in, deadweight 10,075 tons on 27ft 3in mean draught, service speed 17 knots; twelve passengers; three complete decks in holds Nos. 1, 2 and 3 and two decks in holds Nos. 4 and 5, one 80-ton, two 40-ton, two 15-ton, four 7-ton and ten 5-ton derricks, electric deck machinery; three 260kW diesel-driven generators; one set of Parsons triple expansion, double reduction geared turbines, service power 9400 s.h.p. at 106 propeller r.p.m., maximum power 10,340 s.h.p., two Babcock and Wilcox water-tube boilers supply steam at 415 lb per square inch and 750 deg. Fah.—Trial, April 11th and 12th.

JAMOOSA, tug; built by Richard Dunston, Ltd., for The Petroleum Development (Qatar), Ltd.; length between perpendiculars 120ft, breadth moulded 31ft, depth moulded 14ft 6in, static pull 19 tons; air conditioning; three diesel-driven generators, total capacity 135kW; two National mark F4AM8 oil engines, each developing 760 b.h.p. at 500 r.p.m., drive oil-operated reverse reduction gearboxes.—Trial, April.

Catalogues and Brochures

FERRANTI, Ltd., Moston, Manchester, 10.—Catalogue dealing with W.7 range clip-on wattmeter used for the measurement of electrical power in a.c. circuits.

RAINHAM TIMBER ENGINEERING COMPANY, Ltd., Frog Island, Rainham, Essex.—Leaflet entitled "Glued Laminated Timber," describing its uses in timber construction.

LONDON BRICK COMPANY, Ltd., Africa House, Kingsway, London, W.C.2.—Catalogue providing technical information on the full range of "Phorpres" products.

GEORGE H. ALEXANDER MACHINERY, Ltd., Coleshill Street, Birmingham, 4.—Illustrated catalogue dealing with "Jack-Lock" serrated inserted blade milling cutters.

HORWITCH SMITH AND CO., Ltd., Pennett, Staffordshire.—Bulletin No. 0381/82, giving details of the "Griesheim" electrically and gas-heated T.P. welding gun for thermoplastics.

WINN AND COALES, Ltd., Denso House, Chapel Road, London, S.E.27.—Leaflet giving details of "Denso" range of products designed for protecting structural steelwork and pipework.

ELECTRICAL REMOTE CONTROL COMPANY, Ltd., Elremco Works, South Road, Temple Fields, Harlow New Town, Essex.—List No. 104/A giving details of heavy duty multi-circuit sequence timers type HCST used in electrical, mechanical and chemical engineering fields.

ELECTRIC RESISTANCE FURNACE COMPANY, Ltd., 161, Queens Road, Weybridge, Surrey.—Publication R.20, giving a description of the construction and operation of a wide range of furnaces and associated equipment now available to meet the metallurgical needs of the wire industry.

MATTHEW HALL AND CO., Ltd., Matthew Hall House, Dorset Square, London, N.W.1.—Brochure describing by means of captioned photographs some of the services offered by this company to the oil refining, chemical and engineering industries. A brief history of the firm is also given.

W. C. HOLMES AND CO., Ltd., P.O. Box No. B7, Turnbridge, Huddersfield.—Catalogue entitled "Holmes Connersville Meters," dealing with its use as a gasworks station meter and also for the measurement of gas sold in bulk from coke ovens to the gas industry, and for carburetted water gas, oil gas, &c.

LAURENCE, SCOTT AND ELECTROMOTORS, Ltd., 431, Grand Buildings, Trafalgar Square, London, W.C.2.—Booklet giving details of N-S variable-speed a.c. motors supplied for the drive of boiler house and other auxiliaries in British and other power stations. A series of photographs shows some typical installations.

YARROW AND CO., Ltd., Scotstoun, Glasgow.—Illustrated booklet describing the boiler plant installed at Roosecote and Bold generating stations. A folded inset drawing shows the general arrangement of the boiler plant and the acceptance test results are given in a detailed table.

LANCASHIRE DYNAMO HOLDINGS, Ltd., St. Stephen's House, Victoria Embankment, London, S.W.1.—Illustrated booklet describing some of the opportunities provided by the scheme operated within the Lancashire Dynamo group of companies for training as an electrical engineer. Methods of entry are explained and details of the different courses given.

SWITCHGEAR TESTING COMPANY, Ltd., Mosley Road, Trafford Park, Manchester, 17.—Illustrated brochure describing a high-power short-circuit testing station for conducting research into the breaking, making and carrying of short-circuit currents, and for the development and final proving of the short-circuit ability of switchgear, transformers, reactors and resistors.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

ASLIB

Fri. to Mon., June 1st to 4th.—Hotel Metropole, Brighton, Annual Conference.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Wed., May 30th.—GLASGOW BRANCH: 39, Elmbank Crescent, Glasgow, C.2, Annual General Meeting, 7.30 p.m.

Fri., June 1st.—LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, Annual General Meeting, 6.30 p.m.

Sat., June 2nd.—OXFORD, READING AND DISTRICTS BRANCH: "Lewis Room," The Y.M.C.A., 10, George Street, Oxford, Annual General Meeting, 7 p.m.

CHEMICAL SOCIETY

Thurs., June 7th.—Burlington House, Piccadilly, London, W.1, Centenary Lecture, "Present Status of the Transuranium Elements," G. T. Seaborg, 7.30 p.m.

INCORPORATED PLANT ENGINEERS

To-day, May 25th.—BIRMINGHAM BRANCH: Imperial Hotel, Birmingham, "The Legal Aspect of Boiler Operation and Maintenance," G. A. Anderson, 7.30 p.m.

Thurs., May 31st.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, Papers by Members, 7.30 p.m.

Tues., June 12th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Small Industrial Water-Tube Boilers," G. H. Steward, 7.15 p.m.

Thurs., June 14th.—MERSEYSIDE AND N. WALES BRANCH: Royal Institution, Colquitt Street, Liverpool, Brains Trust on "Fuel and the Future," 7.15 p.m.

Fri., June 29th.—BIRMINGHAM BRANCH: Imperial Hotel, Birmingham, "Spring Design and the Plant Engineer," A. A. D. Brown, 7.30 p.m.

INDUSTRIAL WELFARE SOCIETY

Tues. to Thurs., May 29th to 31st.—Robert Hyde House, 48, Bryanston Square, London, W.1, Course of Lectures on "Industrial and Factory Law," by Harry Samuels.

INSTITUTE OF METALS

Wed., June 13th.—METAL PHYSICS COMMITTEE: Weir Hall, Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1, "Some Recent Studies of Irradiation Effects in Metals and Other Solids," R. Smoluchowski, 6.30 p.m.

INSTITUTE OF NAVIGATION

Wed., June 20th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Crossing Antarctica," George Lowe, 5 p.m.

INSTITUTE OF PETROLEUM

Wed. to Fri., May 30th to June 1st.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, Symposium on Chromatrography, 9.30 a.m. to 12.30 p.m. and 2 p.m. to 5.30 p.m.

Wed. to Sat., June 6th to 9th.—SUMMER MEETING: Palace Hotel, Torquay, "Essential Factors in the Future Development of the Oil Industry."

INSTITUTION OF CIVIL ENGINEERS

Tues., May 29th.—WORKS CONSTRUCTION MEETING: Great George Street, Westminster, London, S.W.1, "Kwinana Jetty," Peter Murray and D. N. Collett, 5.30 p.m.

Tues., June 5th.—Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.

Mon. to Fri., June 18th to 22nd.—Great George Street, Westminster, London, S.W.1, Colonial Engineering Conference, Monday at 3 p.m. and following days at 10 a.m.

Wed., June 20th.—Great George Street, Westminster, London, S.W.1, Conversazione, 7.45 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Thurs., June 21st.—Royal Festival Hall, London, S.E.1, Conversazione, 7.45 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., May 26th.—YORKSHIRE GRADUATES' SECTION: Visit to Ferrybridge "B" Power Station and Monk Fryston Switching Station, 10 a.m.

Mon., May 28th.—MIDLAND GRADUATES' SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, followed by Chairman's Address, 6 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., June 7th.—Weir Hall, 10, Upper Belgrave Street, London, S.W.1, "The Planning Performance, Pressures and Stresses in a High-Speed Launch," P. Du Cane, 4.45 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., June 2nd.—N. MIDLANDS REGION: Town Hall, Peterborough, Regional One-Day Conference, "Aspects of Automation," 10 a.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., May 28th.—12, Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5 p.m.

SCIENTIFIC INSTRUMENT MANUFACTURERS' ASSOCIATION

Wed. to Fri., June 6th to 8th.—ELECTRONICS SECTION: Royal West of England Academy, Bristol, Exhibition, "Atoms, Electrons and Industry."

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., May 29th.—Manson House, 26, Portland Place, London, W.1, Annual General Meeting, "Process Analytical Instrumentation," A. G. Stanley and J. F. Brown, 6 p.m.